On-farm Evaluation of Urea Treated Rice Straw and Rice Bran Supplementation on Feed Intake, Milk Yield and Composition of Fogera Cows, North Western Ethiopia

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By

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DEDICATION

This thesis manuscript is dedicated to my lead and beloved elder sister, **Sasulish Mekonnen**, who I lost on 10 September 2006 with the hurtful breast cancer.

STATEMENT OF THE AUTHOR

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Place: Bahir Dar University, Bahir Dar

Date of Submission: ______________________________

LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
AOAC	Association of Analytical Chemists
BoARD	Bureau of Aagriculture and Rural Development
CF	Crude Fiber
CP	Crude Protein
CSA	Central Statistical Authority
DM	Dry Matter
EE	Ether Extract
EME	Estimated metabolizable energy
ESAP	Ethiopian Society of Animal Production
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
ILCA	International Livestock Center for Africa
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
IVOMD	*In-vitro* Organic Matter Digestibility
LSD	Least Significant Difference

masl	Meters above Sea Level
ME	Metabolisable Energy
MJ	Mega Joule
OM	Organic Matter
PA	Peasant Association
RB	Rice Bran
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
NGOs	Non Governmental
NDF	Neutral Detergent Fiber
NFE	Nitrogen Free Extract
SDDP	Smallholder Dairy Development Project
SNF	Solid-Not-Fat
SPSS	Statistical Package for Social Sciences
TDN	Total Digestible Nutrients
TLU	Tropical Livestock
TS	Total Solids
UTRS	Urea Treated Rice Straw
VFA	Volatile Fatty Acid
WoARD	Woreda Office of Agriculture and Rural Development

BIOGRAPHICAL SKETCH

The author was born at Mecha woreda, West Gojjam Administrative zone on 28-06-1973. He attended his primary and junior secondary education at Merawi primary and Junior Secondary school from 1981-1986. The Author had also attended his secondary school from 1987-1990 at Merawi Senior Secondary School. Then he joined Jimma University (the former Jimma College of agriculture) in 1991 and awarded Diploma in Animal Sciences in 1992. In 1993, he was employed at Jabitehnan woreda office agriculture and served for 7 years. Then, he joined Hawassa University (the former Debub University) in 2001 G.C. and awarded BSC degree in Animal science and Range Land Management in 2003. Then, he has been employed in Amhara Agricultural Research Institute, Sekota Dryland Agricultural Research Centre, and worked until 2005 and joined ILRI (International Livestock Research Institute) in IPMS (Improving Productivity and Market Success of Ethiopian Farmers) project as Research and development assistant in Fogera Pilot Learning Woreda and till then in Bure Pilot Learning Woreda. Finally, he joined Bahir Dar University to pursue his graduate studies in Animal Production, besides with his IPMS project works in 2007.

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ABSTRACT

The study was conducted in Fogera Woreda, South Gondar Zone of the Amhara National Regional State with the objectives of on-farm evaluation of urea treated straw and rice bran supplementation on milk yield and composition of Fogera cows. The area has high potential for rice production and is native origin of Fogera cattle breed. Despite the high production potentials, improvements in utilization system for feeding rice straw to livestock are not properly addressed. As a result, assessment of the potentials, opportunities and effects of urea treated rice straw and rice bran on milk yield and composition was required to serve as a basis for the better development of these feeds as potential feed resources for milk production. To address these issues, a single-visit-multiple-subject survey was carried out and 120 rural households who were individually interviewed with structured and semi structured questionnaires. Twenty Fogera cows used for the feeding trial were blocked on weight and milk yield bases having an initial mean body weight of 259.75±33.8 and milk yield of 1.23± 0.26. The treatments were grazing + untreated rice straw(T_1), grazing +urea treated rice straw (T_2), grazing +urea treated rice straw + rice bran (T_3), and grazing +urea treated rice straw + formulated concentrate mix (T_4). The survey result in the study area revealed that 44,223 tons of unhulled rice grain, 38,603 tons of rice straw dry matter, and 4,422 tons of rice bran, respectively were produced in 2008. And the on-farm feed supplementation has resulted in a mean milk yield of 1.2 kg/cow/day in T_1, and 2.36, 2.48, and 2.63 kg/cow/day in T_2, T_3, and T_4, respectively. The partial budget analysis indicated a daily income of 4.20, 6.82, 6.50, and 6.59 ETB, where, T_1 was lesser by a net profit of 2.62, 2.30, and 2.39 over T_2, T_3, and T_4 respectively.

This indicates that supplementary feeding of urea treated straw and rice bran had significant contribution to the development of dairy business in the study area.

Key words: Rice straw, rice bran, concentrate, milk yield, economic analysis

1. INTRODUCTION

Ethiopia has large livestock population in Africa, consisting of 47.57 million cattle, 26.12 million sheep, 21.7 million goats, 7.73 million equines, 1 million camels and 39.6 million poultry (CSA, 2008), contributing considerably to the national economy and the livelihood of the people. The sector shares about 33% of the total agricultural output and 12% of the total gross domestic product (Ayele *et al*., 2003). In Amhara regional state, the livestock population is estimated to be 11.76 million cattle, 9.47 million sheep, 5.47million goats, 2.24 million equines, 0.047 million camels and 12.36 million poultry (CSA, 2008). These showed that Fogera had a great potential and contribution for cattle and poultry production of the region. Irrespective of their number; however, the productivity of livestock in Ethiopia is extremely low in terms of milk, meat production and draught power output (Azage and Alemu, 1998), mainly because of inadequate nutrition, unimproved genetic resources and prevalence of diseases and parasites.

Feed shortage both in terms of quantity and quality is a major problem hindering the development of livestock industry in Ethiopia. The factors contributing to this deficit in dry matter (DM) supply are fast deterioration of the natural grazing land associated with a rise in crop cultivation, over stocking, and recurrent droughts. The tendency of allocating natural grazing lands for crop cultivation has been increasing to satisfy the grain production needs of rapidly increasing human population. In Fogera Woreda only, in 2004/2005 more than 17,937ha of communal grazing land has been transformed to farm lands for crop production (Belete, 2006).

Residues of cereals and pulses account for about 26% of the total feed utilized and ranked second to grazing (64%) in mixed crop-livestock production system of Ethiopia (CSA, 2004). It is also estimated that above 18.5 million metric tons of crop residues are annually produced in the country (Azage *et al*., 2002). Crop residues are generally characterized by low nutritive value, but have potential degradability as high as 80%. They are low in actual digestibility rarely exceeding 50% due to close association of carbohydrates with lignin (Jackson, 1977). A number of studies (Van Soest, 1988; Zhang *et al*., 1995) have also proven that crop residues are low in available nutrients, taking longer lag time and slow in rate of microbial fermentation. These characteristics of straw limit its intake and digestibility; thereby hamper the productivity of farm animals.

In Ethiopia, rice is being well expanded in Amhara, Tigray, Somali, Gambella, Souththern, and Benishangul regions (CSA, 2003). According to a rural households socio-economic survey conducted in Amhara Region (BoARD, 2003), crop residues like straw of teff, barely, wheat, rice, finger millet, maize and residues of pulses were found to be the second largest livestock feed sources during the dry season. The Woreda Office of Agriculture and Rural Development (WoARD) (2008) indicated that, rice production is alarmingly increasing in land coverage and become a major cereal crop, where swampy, water logged and vertisol soils are found. Consequently, rice straw has become one of the dominant farm animal feed resources in the plain areas of Fogera, mostly during the dry season (Belete, 2006). Fogera faced the chance and coerced with the ever rising allocation of arable land to rice production at the expense of grazing land, and other crops (teff and noug) producing land at an average growth rate of 57.84, 101.07, and 163.73% in land coverage, production, and productivity, respectively (WoARD, 2008). This resulted in the contribution of crop residues as livestock feed resource in Fogera to become 68%, where native pasture, aftermath, and browse spp have 25, 5, and 2% share respectively (WoARD, 2007; Ashagrie, 2008). In the mixed cereal livestock farming systems of the Ethiopian highlands, crop residues on the average provide about 50% of the total feed source for ruminant livestock (Jutzi *et al*., 1987). Fogera is also the home of Fogera breed that have better performance in milk and meat production. As a result integration of milk and rice production is important in the mixed farming system of the woreda.

Despite the rising dependence on crop residues as animal feeds, there are still certain constraints to their efficient utilization. However, poor quality roughages such as straws have the potential to improve animal feeds by employing different treatment strategies. Interestingly, China's experience in utilizing tones of annually produced crop residues for ruminants after processing has promoted a marked increase in beef and mutton output, saving a great quantity of grain used for this purpose (Gao, 2000). Utilization of low quality roughages could be improved with supplementation of energy and nitrogen sources, chemical and/or physical treatment, and selection together with breeding of crops, which ultimately depend on the economic benefits and applicability (Ibrahim and Schiere, 1989; McDonald *et al*., 2002). Supplementation of poor quality feeds with nitrogen sources increases the rate and extent of digestion resulting in improved dry matter intake (Preston and Leng, 1987).

Treatment of straw with urea has currently received global attention because of easy access of urea at village level, cheaper price and its ability to break down cellulose besides adding non-protein nitrogen (NPN) to the straw (Sundstøl *et al*., 1978). Treatment of straw with urea helps the ammonia to act upon the fibre and favour the release of soluble carbohydrates and energy for cellulolytic bacteria growth, and further enhancing efficient utilization of roughages. Moreover, urea application is relatively easy, less toxic and effective (Ibrahim and Schiere, 1989). O, Donovan *et al*. (1997) have also reported the importance of urea treatment for improving the nutritive value of cereal straws and its use in the developing countries of the tropics.

According to the data of Fogera Office of Agriculture and Rural Development (2008), rice bran production increased from year to year (2.1 tons in 1994 to 4,422tons in 2008). Farmers do not use it as animal feed; however they sale it to rice polishers with minimum price (0.10 cents /kg), and traders from other areas (Gondar, Woldia, Dessie, Nekemt, and Dangilla) took it mainly for fattening (Belete, 2006). This is due to lack of understanding about the importance and system of feeding of rice bran to their animals.

The cost-benefit analysis and feasibility of using ammoniated straw as animal feed in Ethiopia was reported by Reherahie (2001), and Getu (2006) using concentrate supplement with urea treated barley, teff and wheat straw for crossbred lactating dairy cows. It is very important to note that cost of feeding is the major part of the total cost of milk production (Singh *et al*., 1993), and hence reduction of feeding cost of dairy cows needs to receive due emphasis. Introduction of improved feeding practices based on strategic supplementation of locally available feed resources is required not only to enhance milk production, but also to introduce sustainable farming practice that will ensure a continuous supply of milk and milk products. Accordingly, designed use of rice straw and rice bran supplement to lactating cows will have a sound effect, when its inclusion rate in the daily ration is justified both from the biological point of view and financial returns.

Fogera has a considerable potential and opportunities for development of improved smallholder dairy production both in feed resource and breed, and is still one of the target areas identified for expansion of market-oriented smallholder dairy production in Amhara region (BoARD, 2003). Consequently, Improving Productivity and Market Success of Ethiopian farmers' project has identified Fogera as one of its pilot learning woredas based on the availability of potential commodities for market oriented agriculture that gave an opportunity to improve productivity and market success of farmers, and generate development approaches to further draw lessons to other areas.

Details of information on the productivity and utilization practices of rice straw and rice bran were not well documented. Additionally, the possible and cost effective level and system of rice straw and rice bran feeding for lactating cows was not studied under Ethiopian condition. As a result, due consideration on the assessment, development and evaluation of feeding options with rice straw and rice bran based feeding for milk production was found to be vital in Fogera.

This study was proposed with the objectives to:

1. Assess the productivity, utilization practices, nutritive value, constraints and opportunities of rice straw and rice bran feeding in Fogera
2. Evaluate the effects of urea treated rice straw and rice bran feeding on feed intake, milk yield, milk composition, and profitability in lactating Fogera cows

2. LITERATURE REVIEW

2.1. Features of Crop and Livestock Production System

Mixed crop - livestock farming systems are characterized by interdependency between crop and livestock production activities (Ostergaard, 1995). It is the main system of production for smallholder farmers in many developing countries (Ostergaard, 1995; Blackburn, 1998). The largest share of the total milk and meat available in Ethiopia is produced by mixed farming systems (Ostergaard, 1995).

The principal objective of farmers engaged in mixed crop - livestock farming is to gain complementary benefit from an optimum mixture of crop and livestock farming and spreading income and risks over both crop and livestock production (Lemma, 2002; Solomon, 2004). In the mixed crop livestock farming systems, livestock provide important inputs to crop cultivation, especially manure and traction. Livestock are often the major source of cash that farmers can use to buy agricultural inputs. In turn, crops provide livestock with feed in the form of crop residues and by-products from crop production, which are converted into valuable products like meat, milk, and traction (ILCA, 1992; BoARD, 2003). The potential use of crop residues as livestock feed is greatest in integrated crop/livestock farming systems (Kossila, 1988; Getachew, 2002; Lemma, 2002). Crop residues are required by animals to supply feeds during the dry seasons; while they are also vital to crop. In this regard, it is very likely that changes in the way and time farmers harvest their crops and manage the residues offer a number of possibilities for increasing both crop and livestock production (ILCA, 1992).

2.2. The Role of Nutrition on Animal Productivity

Three factors, viz. genetic makeup; nutrition and management decide the productivity of an animal (Sethumadhavan, 2004). Unfortunately, our animals are low producers because of the shortage of nutrition. Poor nutritive values of feeds lower the production capacity and fertility potential of animals. If we they are fed well, 20-25 % more production can be obtained from the same livestock (Ibid).

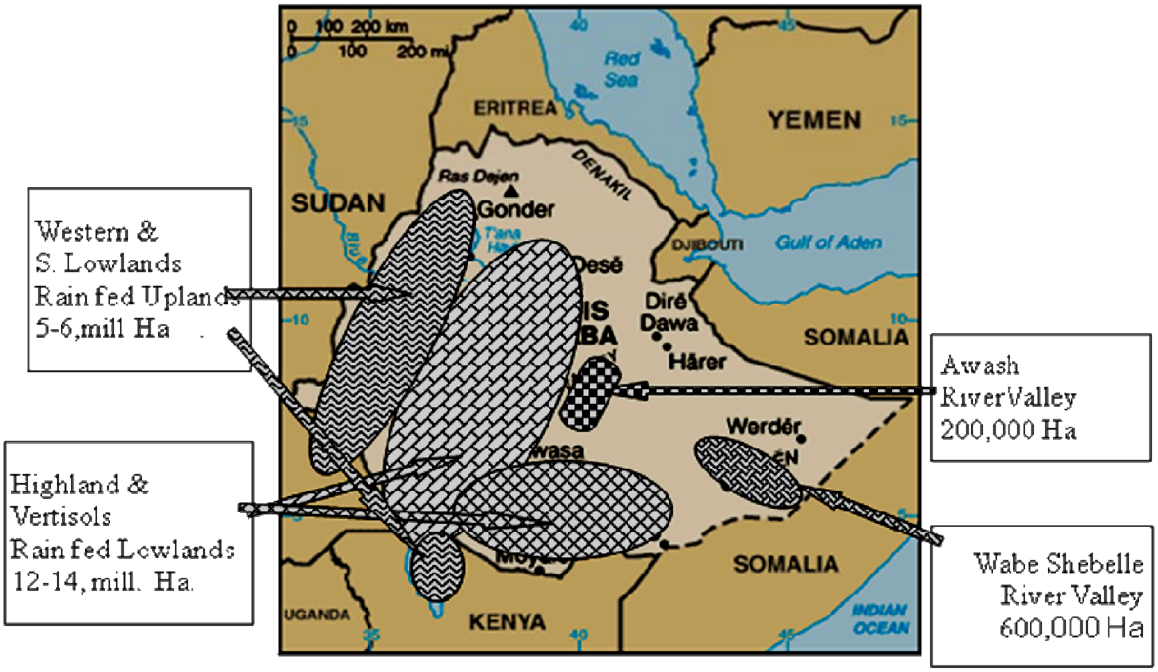
And yet, the feed supply is seasonal and shortage of green fodder is one of the major causes of severe decline of livestock nutrition (Rehrahie, 2001). It is estimated that there is a 40% deficit in the national feed balance. This is again aggravated by seasonal availability of forage and crop residues in the highlands and by erratic rainfall in the lowlands. The common feeds in Ethiopia such as crop residues and matured natural pasture are inherently low in CP, digestibility and intake and are deficient in minerals. The lower nutrient contents reduce rumen efficiency and milk production performance. Lactating cows for example are unable to meet their nutritional requirements i.e., they lose weight and body condition during lactation. The problem is further exacerbated by the associated poor husbandry practices that lower productivity further.

2.3. Rice Production in Ethiopia

World rice production was increased in 2008 by 1.8%, more significantly in all major Asian rice producing countries. Production outlook is also positive in Africa, where high world prices may sustain a 2% growth (FAO, 2008). Studies indicated that Ethiopia has huge potential for rice production. It is estimated that more than 20 million ha of land is suitable for rice production in 3 kinds of agro-ecologies: rain fed low land; rain fed upland and irrigated. Rice production in Ethiopia covers 8.5 thousand ha of land in 4 rice producing regions, and accounted for 0.12 and 0.17% of total area and production, which was under cereal crops, respectively (CSA, 2003).

The Amhara region is the leading rice producer in the country; it contributed the large share in area coverage (78.5%) and volume of production (85.5%) and accounted for 0.28 and 0.48% respectively of the total areas and cereals produced in the region (CSA, 2003). Rice production in Fogera was started by institute of agricultural research (IAR) with two cooperatives and support of North Korean experts, in1974. The development activity was proposed and implemented to Dembia and Metema woredas on trial sites in 1994. In 2002, due to farmers' awareness about relative importance and productivity of the crop, the number of farmers has reached 23,155 and area coverage of 6600 ha in Amhara region

(CSA, 2003). In the same year, the area covered by in Fogera and Metema was 4,020.6 and 187.46 ha, respectively.



Source: SG 2000

Figure1.Rice ecologies of Ethiopia

2.4. Animal Feed Resources in Ethiopia

2.4.1. Available feed resources and their utilization

The fibrous agricultural residues represent a considerable potential feed resource in the populated countries where land must be devoted to human food production as a priority. A comprehensive review of their potential in the developing countries and of the strategies for expanding their utilization has been achieved respectively by FAO (1987). Amongst the world total crop residues maize yields the largest amount; and wheat, rice and pulses each yield about half the amount of maize. The remainder consists of sorghum stovers, barley straws, sugarcane tops and leaves, roots and tubers, oil plants stovers and foliage (Kossila, 1988). In Ethiopian highlands the natural pasture, crop residues, and stubble grazing are major sources of feed(Alemayehu, 2004), whereas, in Fogera the private and communal grazing lands, crop residues of teff, rice, finger millet, barley, wheat, chickpea, maize stalk, hay, agro-industrial by-products and aftermath are the main available feed resources for livestock production (Belete, 2006). It is also estimated that above 18.5 million metric tons of crop residues are annually produced in the country (Azage *et al*., 2002). However, with the decline in the size of the grazing land and degradation through overgrazing and the expansion of arable cropping, agricultural by-products have become increasingly important (Getnet, 1999; Alemayehu, 2004).

Grazing is the predominant form of ruminant feeding system in most parts of the extensive and smallholder crop-livestock farming areas in Ethiopia (Getnet, 1999; Yosef, 1999; Getachew, 2002; Solomon, 2004). The contribution of crop residues to the feed resource base is significant (Seyoum and Zinash, 1998; Getachew, 2002; Solomon, 2004). Under the Ethiopian condition, crop residues provide 40 to 50% of the annual livestock feed requirement (Daniel, 1988, Lemma, 2002). The quantities of different crop residues produced depend on the total area cultivated, the season's rainfall, crop species as well as other inputs such as fertilizers (Daniel, 1988).

Oxen are given priority for feeding crop residues mainly during the peak period of ploughing and followed by weak animals and lactating cows (Mohamed and Abate, 1995; ICRA, 2001). Improved utilization of crop residues can be achieved either through appropriate supplementation (legumes, urea, etc.) or chemical treatment (urea/ammonia) both of which facilitate the microbial breakdown of the cell wall of the crop residues. Moreover, conservation and economic use of crop residues improve and enhance their utilization (Alemu *et al*., 1989; Getnet, 1999). Treatment of fibrous crop residues using urea as a source of ammonia is a technology that can be easily handled by small farmers. However, adoption of the technology has been slow, except in China. The main limitations to the use of by-products in diets for farm animals are the uncertainty of the likely response in terms of animal production and their need for supplementation with other materials to provide a diet adequate for the needs of production. These problems are found at all levels of animal production from subsistence systems to commercial farming.

There are three aspects of feed problems, namely, the issue of increasing the efficiency with which the available feed is utilized (e.g. forages, crop residues, agro-industrial by-products and non-conventional feeds), and the inability to make maximum use of the limited total feed resources as well as the seasonal fluctuations in quantity, nutritive value, and water availability. The inability to feed animals adequately throughout the year is the most widespread technical constraint. Much of the available feed resources are utilized to support maintenance requirements of the animals with little surplus left for production. In drier regions, the quantity of forages is often insufficient for the number of livestock carried; dry season feed supply is the paramount problem. Poor forage quality, that is with low protein and energy content is also a serious problem. Poor quality feed causes low intake rates resulting in low levels of overall production. Crop residues and agro-industrial by-products that could be fed to animals are largely wasted or inefficiently used because infrastructure for transporting, processing and marketing feedstuffs is underdeveloped.

2.4.2. Chemical composition of crop residues and concentrates

2.4.2.1. Crop residues

The species of the plant, the agronomic practice used, soil and temperature, and the stage of growth influence the chemical composition, and palatability of straws. Daniel (1988), Tesfaye (1999) and Solomon (2004) reported that there is a considerable variation in the contents of crude protein and crude fiber. However, the quality varies significantly from crop to crop. Residues from leguminous crops have better quality than the residues from cereals. Legume straws contain less fiber, and high digestible protein than cereal straws (Daniel, 1988; Brannang and Persson, 1990; Tesfaye, 1999; Solomon, 2004).

Crop residues are potentially rich sources of energy as about 80% of their DM consists of polysaccharide, but usually underutilized because of their low digestibility, which limits feed intake (FAO, 2002). These constraints are related to their specific cell wall structure, chemical composition and deficiencies of nutrients such as N, S, P and Co, which are essential to rumen microorganisms. The cell wall fraction includes cellulose, hemicelluloses, lignin, cutin, lignified protein, silica and ash, which are present in most crop residues. Cellulose is the most abundant structural polysaccharide made up of highly ordered glucose molecules linked by β-1-4 glycocidic bond. Hemicellulose is a polysaccharide molecule predominantly composed of xylans with a backbone of xylose, arabinose and glucouronic acid residues (FAO, 2002). The concentration of hemicellulose in grass species varies from 150-400 g/kg DM and is much lower than in legumes which, amounts to between 80-150 g/kg DM (FAO, 2002). Hemicelluloses are partially soluble in dilute alkali. Lignin is a three-dimensional network of phenylpropane units consisting of 5-20% of DM of crop residues. Other components such as cutin, silica and phenolic compounds are associated with the structural portion of the plant limiting its accessibility to microorganisms. The chemical composition of most crop residues was analyzed by different researchers, as indicated in Table 1.

Table 1. Chemical composition of common feed resources in Ethiopia

Feed Resource	DM	CP	Ash	NDF	ADF	ADL	IVDMD	Source
Maize stover	85.7	2.66	7.0	-	42.22	-	48.86	(Yitaye, 1999)
Barley straw	94.0	4.48	19.7	75.06	49.46	9.79	57.51	(Solomon 2004)
Wheat straw	94.2	4.14	8.22	47.58	78.62	10.23	53.92	(Solomon 2004)
Natural pasture	93.9	9.64	10.22	73.58	42.21	5.12	66.83	(Solomon 2004)
Stubble	94.5	3.47	8.57	79.7	55.34	11.24	45.63	(Solomon 2004)
Rice straw	88.9	4.5	17.6	62.4	3.8	-	45.63	(Abebe, 2007)

In India, rice is India's major food crop, with 43 million ha grown. The grain to straw ratio varies between 1:1.3 and 1:3 (FAO, 2002, http://www/fao.org). Rice straw is variable in its chemical composition and ME content. It contains between 4 and 6.5 MJ of metabolisable energy per kg of dry matter. Rice straw is low in CP concentration ranging between 2.0 and 6.0% (Nour, 2003). This is because rice straw contains much more silica (12-16%) and less lignin (6-7%) than other straws which contain 3-5% silica and 10-12% lignin (Nour, 2003). Silica is a mineral with no nutritive value. The silica content of rice straw affects its palatability and, hence, the amount ruminants will eat. Because of the variability of intake between different batches of rice straw, it is important to monitor stock performance when feeding it. The limiting factors for its utilization by ruminants are low CP, high fiber and low available energy contents. Rice straw nutrient composition had also been studied in Egypt and Ethiopia, as indicated in the (Table 1).

2.4.2.2. Concentrates

Agro-industrial by-products are fed as supplement to roughage based diets, particularly in livestock production system for dairy production or fattening activities. Concentrates rich in energy are feedstuffs such as grain, bran, maize middling. Concentrates rich in protein include noug seed cake, linseed cake, cotton seed cake, brewers' grains, etc. How much energy and protein a concentrate mixture should contain will depend on the quality of the basal roughage and the level of production. As a rule of thumb, 1 kg good concentrate will increase milk production by 1.5 kg (SDDP, 1999).

Agro-industrial by-products can be utilized by mixing two or more of the ingredients to make concentrate at home or using a single ingredient. They have special value in feeding livestock mainly in urban and peri-urban livestock production system, as well as in situations where the productive potential of the animals is relatively high and require high nutrient supply. Agro-industrial by-products are rich in energy and/or protein contents or both. They have low fibre content, high digestibility and energy values compared with the other class of feeds. Alemu *et al.* (1989) reported more than 35% CP and 50-70% *in vitro* organic matter digestibility (IVOMD) for oil seed cakes and 18-20% CP and more than 80% IVOMD for flour milling by-products. Therefore, due to their high IVOMD and CP content, supplementing ruminants fed on low quality feeds with agro-industrial by-products enables them to perform well due to higher nutrient density to correct the nutrient deficiencies in the basal diet.

Rice bran is produced from the physical abrasion and separation of the hull from rice grain during the rice milling process. Rice bran blends well with other feedstuffs for mechanical handling and fits well into blended rations. It consists mostly of the bran layer and germ of the rice with some fragments of hull and broken rice. Bran accounts for about 15% of the paddy husk. Rice bran is similar to oats in CP, fat, fiber and energy content (Stephen, 2003). It is a palatable feedstuff, which can be included in the grain mixture at a rate of up to 25 % or fed at a rate of up to 3.6 kg per cow per day and has a percentage composition of 90 DM, 13CP, 13fat, 13crude fiber, 29.7NDF, 16.2ADF, 1Ca, 1.54 P, and 68 TDN (Ibid). Abebaw (2007) indicated that, the chemical composition of rice bran in Fogera contains percentage composition of 93.91DM, 83.53OM, 11.03CP, 40.74NDF, 18.67ADF, 5.87ADL, and 16.5ash during his experiment on sheep ration of Farta sheep.

Noug Seed Cake is a by-product of Noug seed (*Guizota abyssinica*) and has 33.7% CP, and high NDF content of 32.1% which contributes for superior protein supplement as compared to peanut seed cake (Maaza, 1981). Lemma *et al*. (2003) has reported that the chemical composition of noug seed cake is 93.1% DM, 35.5% CP, 28.2% ADF, and 11.1% ash.

2.5. Factors Affecting the Quality and Quantity of Crop Residues

Nutritive value of a given feed is generally determined by nutrient composition, intake and utilization efficiency of digested matter. Species of plants, stage of maturity at harvest, cultivars and leaf to stem ratio are important plant factors determining their nutritive value. For instance, the lower organic matter digestibility (OMD) of wheat stem as compared to the leaf fraction and sheath is due to higher content of NDF and lignin in the stem portion. Contrarily, the OMD of rice straw is lower for its leaf sheath and leaf fraction as the concentration of NDF and lignin is much higher in these parts than in the stem (FAO, 2002). The usefulness and nutritive value of crop residues can also be variable depending on the species of livestock to which it is offered. Cattle, which retain fibrous matter in the rumen slightly longer than sheep have presumable advantage with lower quality crop residues. *Bos indicus* cattle can digest more NDF in rumen and have longer ruminal retention time than *Bos taurus* (FAO, 2002). Environmental factors such as location, climate, soil fertility and soil type have also been found to influence the nutritive values of crop residues. For instance, digestibility of roughage is related to temperature, reflecting a negative correlation with increase in temperature in which high temperature increases the rate of enzymatic process associated with lignin biosynthesis promoting lignifications of cell wall and more rapid metabolic activity resulting in decreased pool of metabolites in the cell (Van Soest, 1988).

2.6. Treatment of Crop Residues

At present, the main treatment methods for forages such as cereal straws are either mechanical (e.g. grinding), physical (e.g. temperature and pressure treatment) or a range of chemical treatments of which sodium hydroxide or ammonia are among the more successful (Greenhalgh, 1984). The use of chemicals to improve nutritive value of crop residues dated back to 1920s when the German scientist, Beckman, used sodium hydroxide to treat stacks of crop residues with consequent improvement in its digestibility. Alkali supply hydrogen ion that breaks down the fiber by saponification of ester bonds in the lignin-hemicellulose molecule. Many chemicals have been used to enhance the digestibility and intake of roughages; the most known ones are sodium hydroxide, sodium sulphate, sodium bicarbonate, ammonium hydroxide, ammonia (Sundstol, *et al.*, 1978), calcium hydroxide and potassium hydroxide.

Among these chemicals, sodium hydroxide has proven to be the most effective in improving digestibility, but lacks nitrogen and less available. The use of alkalis from treatment of crop residues was given less attention after mid 1970s due to high cost and increased environmental pollution. Instead, use of ammonia from urea or other sources has increased in popularity for crop residues treatment.

2.7. Basics of Urea Treatment of Straw

The nutritive value of poor quality roughages like straws and stovers can be improved by different methods of treatment. Urea treatment has, however, emerged as the method of choice for use at farm level in the tropics as it is best adapted to the conditions of smallholder farmers (Chenost, 1995). The major advantages of using urea for crop residue improvement are ease of handling, transport, and do not pose any risk to those handling and using it (Sundstøl and Coxworth, 1984). Moreover, fertilizer grade urea is readily available and relatively cheap compared to either aqueous or anhydrous ammonia. Urea treatment is a two-stage process consisting of ureolysis, where urea is converted to ammonia and the effect of generated ammonia on the cell walls of the forages being treated (Chenost, 1995). The hydrolysis of urea (ureolysis) proceeds according to the following reaction: NH_2 (CO) NH_2 + H_2O → $2NH_3$ + CO_2 (Sundstøl and Coxworth, 1984). The key to improve the use of crop residues for ruminants is to overcome the barriers to rumen microbial fermentation of lignocelluloses. The two well known factors of rice straw that limit bacterial digestion in the rumen are its high level of lignifications and low contents of nitrogen, vitamins and minerals. Therefore, in principle, there are two approaches, which should be taken in combination, straw delignification treatment and nutrient supplementation.

2.8. Methods of Urea Treatment

There are many variations in the methods of treatment of low quality roughages with urea. However, the principal method consists of dissolving urea in water and sprinkling it on layers of straw. The level of urea used varies, but it is commonly between 4%-5% of air dried mass of the straw/stover, and the amount of water used also varies from as low as 0.2 liters per kg of straw to as high as 1 liter per kg of straw (Sundstøl and Coxworth, 1984; Chenost, 1995). The treatment of the straw can be done in pits, using polyethlene sheets as inner linings. Airtight conditions are important during the treatment period, especially for small quantities of straws. Polyethylene sheet is very effective for excluding air, but a number of locally available materials such as banana leaves, soil, jute bags and cow dung are also used (Sundstøl and Coxworth, 1984). The treatment period depends on the temperature of the surrounding and may be as low as 1 week in warm areas and up to 8 weeks in cold environment (Chenost, 1995).

2.9. Factors Affecting Urea Treatment of Straw

The effectiveness of urea treatment depends on factors that influence ureolysis. These are the presence of urease, moisture, temperature, duration of treatment, application rates, type, and quality of straw are the major ones.

2.9.1. Presence of urease

Urease particularly affects the process of ureolysis that requires the hydrolysis of urea to ammonia in the presence of the enzyme urease in the straw or stover to be treated (Sundstøl and Coxworth, 1984; Chenost, 1995). Some straws are deficient in the enzyme, whereas others have adequate amounts. Studies have shown that urease produced by ureolytic bacteria during treatment of crop residues is sufficient when humidity is not a limiting factor (Chenost, 1995), but addition of urease is necessary where low amounts of water (20 to 25% of stover/ straw weight) are used during the treatment of straws (Chenost, 1995).

2.9.2. Moisture content

The moisture content of crop residues to be treated is critical for the success of urea treatment (Chenost, 1995). In the application of moisture during urea treatment of crop residues, more emphasis should be given to the final moisture content of the crop residue rather than the quantity of water to be added which is recommended to be between 30-60% for effective ureolysis and ammoniation of straws (Chenost, 1995). Final moisture content of less than 30% in urea treated crop residue reduces severely the process of ureolysis and hence, the ammoniation process as a whole. It may as well result in loosely packed material as it causes difficulty of compression and packing. Poor ureolysis produces inadequate ammonia (which has preservative properties) and along with too much oxygen under moist conditions leads to bad treatment and molding. Moisture level above 50 to 60% leads to compaction problems, downward leaching of urea solution and insufficient diffusion of ammonia (Chenost, 1995). Within the recommended range, the amount of water to add can be adjusted according to local circumstances such as environmental temperature, humidity and the moisture level of the material to be treated.

2.9.3. Temperature and treatment duration

The optimum temperature for ureolysis lies between 30- 60^{o}C, and the rate of ureolysis doubles or decreases by a factor of 2 for every 10^{o}C rise or fall in temperature, respectively (Chenost, 1995). Ureolysis can be completed within 1-7 days at temperatures between 20^{o}C and 45^{o}C. However, the activity of urease is severely reduced or even canceled when temperature falls below 5^{o}C to 10^{o}C (Chenost, 1995). This is attributed to the reaction of carbon dioxide and ammonia to form ammonium carbonate at low temperatures in sealed stacks. However, the negative effect of low temperatures can be largely compensated for by increasing the treatment period (Sundstøl *et al.,* 1978; Chenost, 1995).

On the other hand, the actual ammoniation process is accelerated by increasing temperatures to a limited extent. Increasing temperature showed a positive effect up to 45^{o}C when short treatment periods were used. The ammoniation process is influenced by the ambient temperature which in turn influences the duration of treatment that may range from one week to eight weeks (Sundstøl and Coxworth, 1984; Chenost, 1995). Sundstøl *et al.* (1978) found out that the effect of treatment length increased up to 4 weeks at 17^{o}C - 25^{o}C, whereas at lower temperatures (-2^{o}C and +4^{o}C) the increment of treatment length could continue to the eight weeks of treatment. Due to a relatively warm temperature requirement, urea treatment is more effective in tropical than in temperate regions.

2.9.4. Application rates

Most experiments (Sundstøl *et al.,* 1978; Chenost, 1995) indicated little improvements in digestibility from increasing the level of ammonia above 3 to 4%. However, Chenost (1995) recommended treating straw with 5% urea as it has produced satisfactory results in Africa and Asia.

2.9.5. Straw type and quality

It has been noted that the effect of treatment is more pronounced for stovers/straws whose initial quality is very poor compared to those with better original quality. The difference in ways of different straws or varieties of straws to react with urea can be explained by the degree of hemicellulose-lignin linkage (Chenost, 1995). Sundstøl *et al.* (1978) has found that legume straws are less responsive to ammoniation compared to grasses since legumes contain fewer phenolic bonds and their lignin is less soluble in alkali.

2.10. Intake, and Digestibility of Straws and Rice Bran

Maximum intake will likely reach 3.5%-4% of their body weight for most cows, but can vary with production and an individual cow's appetite (Schingoethe, 1998). Preston (1985) reported that ammoniation usually increases digestibility by 5-10%, nitrogen content by 1-2% DM and voluntary intake by as much as 50% when offered free choice. Most data reviewed (FAO, 2002; Rehrahie, 2001) have shown decreased NDF and ADL, and a considerable increase in CP contents of the crop residues due to ammoniation. The CP content of treated straw is always higher than untreated straw indicating the effectiveness of treatment. Fall *et al.* (1989) indicated that urea treatment improved intakes (g/kgW$^{0.75}$) from 48 to 61 with the corresponding improvement in digestibility (g/kg DM) from 428 to 545 for untreated and treated rice straw, respectively. Maximum use of straws as a feed for ruminants depends on efficient fermentation by rumen microorganisms.

Feeding rice straw should not exceed 25%, but could be increased to 50% if fed with supplements of feed having 14% CP or the entire ration with 2 pounds of tested liquid or block supplement (ANR, 2002). The rice agro-industrial by-products (rice polishing, rice bran) can be fed together to support high levels of production. This feeding package is suited to the northern and southern part of Senegal (www.fao.org). Islam *et al.* (2002) estimated the rumen degradability of rice bran protein as a percentage of the total protein in rice bran to be 64.3, 50.0, and 41.4% assuming rates of passage of 2, 5, and 8%/h, respectively. Chaudhary *et al.* (2001) observed that it may not be necessary to have additional protein supplementation for lactating cows to improve the performance of cattle supplemented with de-oiled rice bran; however, providing additional, rapidly degradable carbohydrates may help balance the ruminally degradable N to ruminally degradable OM, possibly improving performance through improved intake, microbial efficiency, and increased VFA production.

2.11. Effect of Feeding Urea Treated Straws on Milk Yield, and Composition

The major constraints to milk production on diets based on crop residues appear to be insufficient glycogenic compounds to provide the glucose for lactose synthesis and for oxidation to provide the NADPH for synthesis of fatty acids (Preston, 1986). Therefore, in order to improve milk production levels, energy inputs such as concentrate feeds have to be considered essential for any dairy enterprise; even for those based on dual purpose systems, since reduced intake of energy by animals consuming low quality forages is the principal cause of low milk production. In India and Sri Lanka using urea treated rice straw (4%) supplemented with 1-1.5 kg/day of concentrate resulted in an extra milk yield of 1-1.7 kg/d (Perdock *et al.,* 1982). An increase in milk production from 160-300 liter/cow was recorded in Niger over a four-month period after providing an evening feed ration of urea treated straw. In Madagascar, milk production with an average increase of between 1 to 1.5 liter/day for local or crossbred cows was noted.

In a feeding trial conducted using lactating crossbred cows in Ethiopia, urea treated barley or teff straw were noted to replace native hay, and ammoniation was found to be economically feasible producing about 6.2 kg milk/ day for teff (Reherahie, 2001) and 5.6 kg milk/ day for wheat straws (Getu, 2006), but the milk yield composition (milk fat, milk protein, lactose, and total solids) is not significantly affected by feeding urea treated straw (Reherahie; 2001, Getu, 2006). Milk composition of cross bred cows, in Holeta has a percentage share of 4.5, 3.62, 4.15, and 14.03 of Fat, protein, lactose, and total solids (Getu, 2006).

2.12. Economics of Feeding Urea Treated Straws for Milk Production

There has to be a good economic reason and visible effect for farmers to feed urea treated straw. The cost of feeding is a major part of total cost of milk production (Singh *et al.,* 1993), and hence reduction of feeding cost of dairy cows is a major concern. The cost of concentrate is high compared with straw and fresh forage. Vijayalakshmi *et al.* (1988) indicated the milk yield at early, mid and late lactation in cows both at rural and urban Banglore, India has clearly shown that urea treated straw based feeding to be economical. When fresh forages are scarce and expensive, the use of urea treated straw as an alternative feed holds a promise, and treatment is not too costly. Much work has not been done in this aspect, but some reports (Sampath, 1989) indicated that using urea treated straw in feeding animals reduced the cost of maintenance and milk production. Feeding experiments with treated barley and teff straw using concentrate as a supplement by Reherahie (2001) has also proven to be economically feasible in Ethiopia. Treatment of straws with urea is the most promising alternative solution in order to enhance straw utilization by ruminants. Even if, use of cereal straws and stovers as an animal feed in Ethiopia has a long standing history, farmers have not yet applied the already developed methods for improved utilization of straw as feed. Rehirahie and Ledin (2004) indicated that the ever developed methods seem not technically and socio-economically suited to the local conditions under which small poor farmers are dominant. As a result, during developing methods for improvement of straw feeding system, the local physical environment, and socio-economic conditions must be considered.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Fogera woreda in south Gondar Zone of the Amhara National Regional State. The total land area of the Woreda is 117,405 ha with an altitude ranging from 1774-2410 masl. It is located between $11^0 58'$N latitude and $37^0 41'$E longitude. The average annual rainfall is 1216.3 mm and the annual minimum and maximum temperatures are 16^oC and 20^oC, respectively (IPMS, 2008). The climate is characterized by warm temperature with uni-modal rainy season and predominantly classified as Woina-dega in agro-ecology. The topography of the Woreda comprises 76% flat land, 11% mountain and hills, and 13% valley bottom (IPMS, 2008). According to the Woreda Office of Agriculture and Rural Development (2008) the dominant (65%) soil type in the Fogera plains is black clay soil (*Pellic Vertisol*). The total human population of the Woreda is about 246,541 of which 126,478 are males and 120,063 are females (WoARD, 2007). Over 90% of the community members are dependent on subsistence agriculture. The farming system is characterized as mixed crop-livestock production system. The livestock population of Fogera is estimated to be 157,128 cattle, 27,867 goats, 7,607 sheep, 13,536 equines, 246,496 poultry, and 21,883 beehives (CSA, 2003).

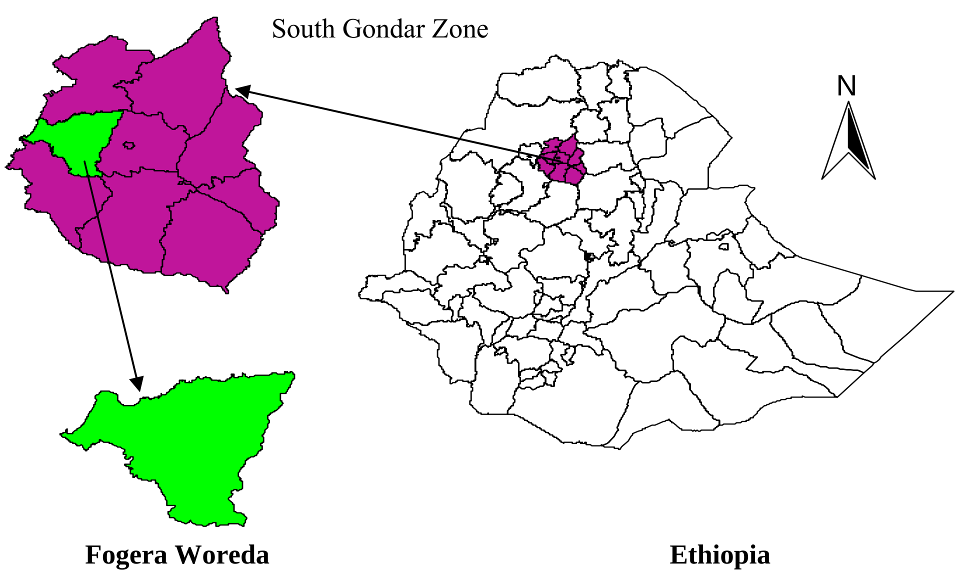


Figure2.Map of Fogera woreda

3.2. Survey on Animal Feed Production and Utilization

To identify the production and feeding practices, preliminary visits were made to rice growing peasant associations (PAs) to develop questionnaire which was applicable to the objectives of the study. Both structured and semi-structured questionnaires were prepared and used for the survey. Secondary data sources were also employed from Woreda Office of Agriculture and Rural Development (WoARD). Rice production is highly related to water availability, since it needs more water and even grow well in floody areas than other crops. As a result, peasant associations that grow rice were identified and classified into three groups of water drainage situation (flooding level). In water logging (flooded) plain it consisted of Shina, Kidst Hana, Wagtera, Nabega, Shaga, and Abua kokit , while for paddy fields which have better water drainage includes Kuhar Michael, Kuhar Abo, Woreta Zuria, Rib Gebriel peasant associations. The uplands also included Tihua Zakena, Woji, Adis Betechristian, and Diba Sefatra peasant associations. Accordingly, one representative PA per each category was selected based on potentiality and variation in drainage situation to undertake the survey works. For water flooded plain (Shina), and to paddy fields (Kuhar Abo), while for uplands (Tihua Zakena) PAs were selected

For the field survey, the method of data collection was single- visit-multiple-subject survey (ILCA, 1990). Both formal and informal surveys were used to identify the production and utilization system of rice crop in the study woreda. Forty farmers per each PA; that have different land, wealth, marriage and age groups were randomly selected which totally make 120 respondent farmers. Enumerators were trained and the actual data were collected under the close supervision of the researcher. Secondary data were also considered.

3.2.1. Survey and feed sample collection

Data with respect to household characteristics like sex, age, family size, education level and economic variables such as land holding, livestock population and crop production situation of the farmers were collected. Farmers' indigenous knowledge and practices in harvesting time, post harvest management, feeding, and marketing of rice straw and rice bran were also recorded. The potentials, constraints and opportunities of rice production and utilization of straw and polishing by-products (rice bran and husk) were identified and collected. Nine sub-samples of rice straw were collected and mixed (3 samples per PA) to form three samples per location category for chemical analysis. Estimates on availability of crop residues usually depend on harvest indices under research condition assuming certain field losses (Nordbloom, 1988). About 10% of the crop residues was considered as wastage either during utilization or used for other purposes or both (Adugna and Said, 1994). In rice production the harvest indices of rice grain and straw was 1:1 Devendra (1997), while FAO (1987) was estimated it at 1:1.5 ratio. In the study area, the rice straw was estimated based on rice grain to rice straw ratio obtained from samples taken from farmers' field. Rice bran was estimated with respect to its proportion of grain yield (10%) and/or husk (1:3 rice bran to husk ratio) produced during rice polishing process.

3.2.2. Household data collection

Data with respect to family size, age, sex, education, land holding and use pattern, livestock holding, awareness to different technologies, production and utilization practices, constraints and opportunities to use rice straw, and bran for future development were identified and collected in the sample PAs with the survey.

3.3. Experimental Feed Preparation

The urea treated rice straw was incubated in underground constructed pit of 2m*1m*1m dimension with a capacity of 180-200 kg of urea treated rice straw. The entire wall was lined with polythene sheet. The ratio of water: urea: straw used was 20:1:20 kg as per the recommendation of Chenost, (1995). The solution of urea and water was uniformly sprayed and mixed to properly incorporate the solution into the straw on batch bases with 20 kg of straw and water each with 1 kg of fertilizer grade urea. Further batches were made with similar procedures up to the capacity of the pit. Layers of treated straw were placed in a pit and trampled over with feet sequentially until sufficient compaction was attained. Thereafter, the treated straw was completely covered and sealed with a polyethylene sheet from all sides to prevent the entrance of oxygen, and ammonia from evaporating to attain adequate fermentation during the treatment and storage process. The duration of treatment was 21 days. After 21 days, urea treated rice straw was aerated for a minimum of 12 hours prior to feeding to facilitate the escape of free ammonia as described in Misra *et al.* (2006). A concentrate mix that has been assumed to be sufficient for the entire experimental period was formulated with Pearson square method by taking rice bran and noug cake as main ingredients in such a way that the formulated ration comprises of 74, 25 and 1% rice bran, noug seed cake and salt, respectively. A concentrate mix of 0.25 kg/kg of milk yield was given (Holeta Research Center, 2004 as cited by BoARD, 2005) and assumed to fully meet the requirement for major nutrients of lactating indigenous cows with milk yield of 4-6 lit /day and a butter fat content of 4%.

3.4. Experimental Animals and Design

In three adjacent PAs (Kuhar Abo, Kuhar Michael, and Shina) that have similar grazing area and management system were selected. Twenty farmers, each having one lactating Fogera cow at early to mid lactation (about 2-8 weeks after calving) was selected for the on-farm feeding trial based on their willingness to undertake the experiment and commitment for data collection and monitoring of feed intake and milking. Average body weight of the selected cows was 259.20±32.47 kg ranging from 210 to 356 kg with an average initial milk yield of 1.23.8±0.26 kg/cow/day ranging from 0.8 to 1.6 kg/cow/day. All cows were equal in parity (second) and treated with Fasinex 900 g (3.6 g/kg body weight of cow) to treat fasciola, Ivermectin injection (0.02 ml/kg cow) to treat internal and external parasites like menge, ticks, lice, nematode and trematode except fasciola, and Diminazin (0.05 ml/kg cow) to treat trypanosomosis prior to the start of the experiment. The cows were assigned to each treatment with randomized complete block design based on their initial weight, and initial milk yield.

The treatments include:

T1 = Grazing + untreated rice straw *ad lib*

T2 = Grazing + treated rice straw *ad lib*

T3 = Grazing + treated rice straw *ad lib* + rice bran

T4 = Grazing + treated rice straw *ad lib* + formulated concentrate mix

3.5. Experimental Diets and Feeding Management

The dairy cows were assigned and fed with four feed treatment groups for a period of 45 days to collect feeding response data and with an adaptation period of 15 days. The initial and final body weights of the experimental cows were estimated using heart girth measurements. Animals were allowed to graze 10 hours from 7:00 am to 5:00 pm and recommended amount of supplements were given half in the morning at 7:00 am and the remaining half in the afternoon at 5:00 pm. Water was provided *ad libitum*. The cows were fed the supplementary feeds individually. Samples of feed offered from all diets and refusals from experimental cows were collected, weighed on daily basis and bulked on a weekly bases and oven dried at 65^{o} C for 72 hours to determine daily feed DM intake and for chemical analysis. Body weight change was recorded at the beginning and end of each experimental period for each treatment to monitor live weight changes across periods for each dietary treatment.

3.6. Data Management and Statistical Analysis

Management of data sets in the experimental period and their statistical analysis included data and analysis of survey, feeds of experimental cows, feeding of cows, milk yield composition and economics of feeding experiment.

3.6.1. Household analysis

Data with respect to family size, age, sex, education, land holding and use pattern, livestock holding, awareness to different technologies, production and utilization practices, constraints and opportunities of rice straw, and bran for future development were properly filled and coded in a computer. The analysis was handled using the Statistical Package for the Social Sciences (SPSS, 16.0) soft ware and summarized, and analyzed for descriptive statistics and frequencies.

3.6.2. Feed sample analysis

All samples of feed offered and refusals were analyzed for DM, N (Kjeldahl-N) according to AOAC (1990) procedures. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the methods of Van Soest and Robertson (1985). *In vitro* organic matter digestibility (IVOMD) of feeds offered were determined using procedures outlined by Tilley and Terry (1963). Hemicellulose was calculated from the difference between NDF and ADF. Metabolizable energy (EME) value was calculated from the IVOMD as follows;

ME (MJ/kg) = 0.16(IVOMD) according to McDonald *et al* (2002).

Where:

IVOMD = *In-vitro* organic matter digestibility

3.6.3. Milk yield and composition analysis

All the cows were hand milked twice a day (7:00 am in the morning and 7:00 pm in the evening) and milk yield measurements were taken by using graduated cylinder every day throughout the study period. Every fifteen days interval, 100 ml of morning and afternoon milk samples of mixed composite were taken using a glass measuring cylinder for each cow after the completion of the adaptation period. The milk samples were used to determine percentage of fat, SNF, protein, total solid, and ash.

For milk yield analysis a daily milk record (morning and evening separately) was taken by individual farmers themselves and enumerator. And one hundred milliliter composite milk samples (morning and evening milking) were collected from each experimental cow fortnightly for a period of 45 days. The samples were collected with a labeled container, kept in an ice box and delivered to Bahir Dar University, Engineering Faculty, school of Food Technology and Processing for analysis of chemical composition. Chemical composition was determined following standard methods of Marth (1978).

Fat composition: - Fat content of the milk was estimated using the Gerber analytical method (British Standard Institution B.S., 696, 1955). This is based on the principle that fat in milk exists in the form of an emulsion which is stabilized by phospholipids and proteins. The theory of the Gerber method is based on the fact that the fat globules are de-emulsified by the addition of concentrated sulphuric acid (H_2SO_4). The free fat, with a lower density than the surrounding medium, may be separated rapidly by centrifugal force. Ten ml of sulphuric acid was dispensed into a butyrometer. Then, 11 ml of milk and one ml of amyl alcohol were added into a butyrometer having the sulphuric acid. The butyrometer was then tightened the stopper and the sample was shaken and inverted several times until all the milk was digested by the acid. Then the butyrometer was placed in a water bath at 65ºC for five minutes. The sample was centrifuged for five minutes at 1100 rpm. Finally, the sample was returned back to the water bath and kept for 5 minutes at 65ºC and fat percentage was read from the butyrometer scale (O'Connor, 1994). Those samples having higher or lower percentages beyond the normal fat ranges were rejected. Finally, average of duplicate samples was computed and precession of analysis was determined at 5 % level.

Protein composition: - The formaldehyde titration method was used to determine the total protein content of milk (O'Connor, 1994). The principle is that when formaldehyde is added to milk the free amino groups of the protein react with the carbonyl groups of formaldehyde causing the milk to become acidic. The acidity developed is related to the amount of protein present which may be measured by titrating with sodium hydroxide (NaOH) using phenolphthalein as indicator. Ten ml of milk was added into a beaker. Then 0.4 ml of 0.4 percent potassium oxalate and 0.5 ml of 0.5% phenolphthalein indicator were added into the milk. It was allowed to stand for two minutes and then the mixture was titrated with 9N (normality) sodium hydroxide solution until pink color was obtained. At this stage, two ml of neutral 40% formalin (the formalin solution was made neutral by adding a few drops of phenolphthalein and then adding sodium hydroxide drop by drop until a faint pink color was obtained) was added to discharge the pink color. The titration was continued until a pink color of equal intensity was again obtained. Finally, the number of ml of the N/9 NaOH used after the addition of formalin multiplied by 1.74 gave the percentage protein in the milk (O'Connor, 1994).

Total solid composition: - To determine the total solids content 5 gm of milk sample was placed in weighed and dried crucibles in duplicates. The samples were kept at 102ºC in a hot air oven for 3 hours. The dried samples were taken out from the oven and placed in desiccators to cool and finally weighed (Richardson, 1985). Total solid was calculated using the following formula:

$$Total\ solids = \left(\frac{Weight\ of\ dried\ sample}{Sample\ weight} \right) \times 100$$

Solid not fat composition: - The solid-not-fat (SNF) content was determined by subtracting the percent fat from total solids (O' Mahony, 1988).

Total ash composition: - The total ash content was determined by igniting the dried milk samples in a muffle furnace in which the temperature was slowly raised to 550ºC. The sample was ignited until the carbon (black color) disappears and a light grey or white ash remains (Richardson, 1985). Total ash content was calculated using the following formula:

$$Total\ ash = \left(\frac{Weight\ of\ residue}{Weight\ of\ sample} \right) \times 100$$

3.6.4. Statistical analysis

Voluntary DM intake, milk yield, and composition were analyzed with General Linear Model (GLM) procedure of SAS (2000) for least square analysis of variance. Mean comparisons were done using Duncan's Multiple Range Test (DMRT) for variables whose F-values declared a significant difference. Differences were considered statistically significant at 5, 1, and/or 0.1% significance level.

Initial milk yield was used as covariate to adjust milk yields during experimental period and the model used for data analysis of all parameters was:

$Y_{ij}=\mu+R_i+W_j+E_{ij}$, Where,

Y_{ij}=the dependent variable (milk yield, composition and weight gain)

μ= the overall mean

R_j=the effect of the i^{th} ration

W_j=the effect of the j^{th} block

E_{ij} = random variation

3.6.5. Partial budget analysis

A simple partial budget analysis was carried out based on calculations of the total cost of supplemental feeds (rice bran, noug seed cake, and treated rice straw) and considering milk sales price and labour cost incurred during the entire experimentation process. The milk price was fixed based on the milk price paid to farmers by the Dairy Cooperatives of Fogera. The prices of the rice bran, rice straw, urea, and ensiling materials were obtained from the current market price during the experimental period. Partial budget analysis was employed to compute total cost of production /cow/day, mean milk yield/cow/day, price of milk/cow/day, cost of production/litre of milk, return/cow/day, net return/cow/day.

4. RESULTS AND DISCUSSIONS

4.1. Household Characteristics

The entire sampled farmer households, (100%) were Orthodox Christians. As indicated in Table 2, the average age of the respondents was 36.9 years with the average household size of 5.14 persons. The mean age of Tihua PA (34) was higher than K/Abo (36) and Shina (40) that indicated the involvement to rice production was correlated with increased age. Family size in interviewed households in each PA indicated that higher in Shina that other PAs, which might be better awareness to family planning and availability of land per household.

Table 2. Household characteristics of the surveyed PAs

Variables	Max	Min	Mean	SE
Mean age (years)	**57**	**22**	**36.7**	**2.74**
Shina PA	53	22	34	2.81
K/Abo PA	43	27	36	2.64
Tihua PA	57	32	40	2.77
Family size (Number)	**10**	**3**	**5.14**	**0.8**
Male	**6**	**1**	**2.55**	**0.4**
Shina PA	6	1	3.5	0.5
K/Abo PA	6	1	2.7	0.4
Tihua PA	5	1	1.45	0.3
Female	**8**	**1**	**3.2**	**0.3**
Shina PA	8	1	4	0.4
K/Abo PA	6	1	3.5	0.4
Tihua PA	4	1	2.1	0.1

SE= standard error

In this finding, the proportion of family members who can read and write (46.67%) which exceeds the proportion of illiterate, elementary and high school levels with 15%, 29.17%, and 42.5% respectively. As indicated from Table (3), 85% of the population was literate and able to read any written materials and understand it. Since education is an important tool to bring fast and sustainable development and had roles in affecting household income, adopting technologies, demography, health, and as a whole the socio-economic status of the family as well. This might had a good contribution to adopt technologies to the study area.

Table 3. Educational status of sample respondents

Educational status	Number of respondents	Percent
Illiterate	38	31.67
Read and write	56	46.67
Elementary school	21	17.50
High school	5	4.17
Total = N	120	100.00

N= no of respondents

4.2. Land Holding and Land Use Pattern

The average land holding size of the respondents was 1.14 ha which is lower than the mean land holding of Amhara region (1.7 ha) by 0.56 ha (SAERP, 1996). The average pasture land size of the respondents was 0.25 ha as compared to 0.84 ha (Ibid). As indicated from the Table (4), more emphasis was given to production of rice crop than other crops that covered 74.5% of the farm land which have relatively equal share as compared to 79.65% the total cereal share of the country ((CSA, 2008). This crop production pattern of Ethiopia showed that cereals contribute most of the feed resources as crop residues, and rice straw and rice bran as well became the highest contributors of animal feed resources in the study area showing more attention should be given to utilization of rice crop products as animal feed.

Table 4. Land use pattern of rice growing peasant associations in Fogera woreda

Variables	Maximum	Minimum	Mean	SE
Crop land _owned (ha)	3	0.375	1.14	0.18
Crop land _ rented (ha)	0.75	0. 25	0.1625	0.43
Rice crop land (ha)	3	0.325	1	2.7
Rice_ land share % (ha)	80	52	74.5	-
Private pasture land (ha)	0.5	0	0.25	0.12

SE= standard error

4.3. Livestock Holding

The mean livestock holding per household was 7.3 with maximum of 14 and minimum 5, similar to that reported by Belete (2006) indicating a mean livestock holding of 7.3 per household. As indicated in Table (5), the predominant livestock species kept in the area include cattle, sheep, goats and donkey where the cattle population shares 57%. The population of cattle in the study area accounts 0.33% and 1.34% of the country and the Amhara region, respectively. This study indicated that cattle production was more important and given better attention due to their socio economic values which includes milk, meat, traction, marriage, wealth assets and social prestige. Most of the respondents (69.4%) have 1 to 7 cattle in their household, and 30.6% respondents have 8 to 14 cattle in their household. The private grazing land (Table 4) was too small as compared to the livestock holding, which indicated that livestock herding was based on communal grazing lands.

Table 5. Livestock holding of rural households in Fogera woreda

Variables	Maximum	Minimum	Mean	SE
Livestock holding (number)	20	6	12.85	7.25
Cattle (number)	14	1	7.3	3.84
% of cattle	0.7	0.17	57	-

SE- standard error

4.4. Feed Resources and Feeding

The types of feeding systems noted from this study were communal grazing, stall feeding. As indicated in table (6), the major sources of feed in the study had were crop residues, natural pasture, hay, and crop aftermath. Concentrates were rarely used with except to those small holder dairy producers of Woreta town who keep crossbred cows. Generally, crop residues from cereals such as rice straw, finger millet straw, teff straw, wheat straw, barley straw and maize stover form the basal diets of the animals. This finding is in line with the report of Belete (2006) and Ashagrie (2008), who found out that the major basal feed resources for cattle in Fogera woreda are crop residues, the privates and uncontrolled communal grazing lands, conserved forage such as hay, and the aftermath. Crop residues provided the major feed (68%) followed by grazing land (25%) and aftermath (5%) in the study area (Table 6). It was believed to be a good beginning for better use of pastures in private grazing land but reserving was limited due to shortage of farm land.

Feed shortage was encountered by farmers both in the dry and the wet seasons in the study area; where it was severe from January to May of the dry season (Table 7). To overcome these seasonal shortages of feed, the respondents' practice various coping mechanism through conservation of hay, crop residues and supplementation of legume green feed sources mainly grass pea. No one of the respondents exercised of urea treatment of crop residues.

According to 99% of the respondents (Table 7), there was a presence of feed shortage mainly during January to May (86.3%) followed by July to September (13.7%). As indicated in table (6), feed shortage was resolved mainly with conservation of crop residues (68%), pasture grazing (21.5%) and hay (3.5%), which illustrates the dependence of farmers on crop residues for livestock feed. The main problems encountered in the area were shortage of pasture land (52.9%), since the grazing lands were changed to rice farm lands, water logging (26.5%) specially bordering to Lake Tana around 6 PAs are seriously affected in wet season, and invasion of noxious species the dominant was Amicala (*Hygrophila auriculata*) (20.6%).

Table 6.Major feed resources, availability and their utilization in Fogera woreda

Type of feeds	Time of availability	Feeding system	Percentage	Rank
Straw			**68**	**1st**
Rice	December - June	Stall feeding		
Maize	January - May	Stall feeding		
Finger millet	February - June	”		
Teff	December - June	“		
Barley	March - June	”		
Wheat	March - June	“		
Native pasture			**25**	**2nd**
Green grass	June - November	Free grazing		
Hay	March - May	Stall feeding		
Aftermath	**October - February**	**Free grazing**	**5**	**3rd**
Browsing fodder and tree legumes		**Free grazing**	**2**	**4th**

Source: Fogera district Agricultural and Rural Development Office, (2008) and Ashagrie, (2008)

Farmers in the study have perceived that feeding supplements were important and know the presence of supplements mainly noug seed cake, but they fear the price incurred in purchasing and did not compared the profit obtained at the expense of supplementation as compared to their traditional practices. On the other hand, they did not have the knowledge and practice of using rice bran as a supplement, since it is considered as useless and wrong perception of decreasing tendency to decrease milk yield. The survey indicated that awareness creation and skill training requirement on the utilization of supplements to animal feed and observe the effects and cost benefits.

Table 7. Feed problem assessment of Fogera woreda

Description	Percent of respondents	Time (months)
Do you encounter feed shortage?		
Yes	99.2	
No	0.8	
When occur?		
Wet season	13.7	July to September
Dry season	86.3	January to May
Do you supplement?		
Yes	74.6	
No	25.4	

The dominant crop residues in the study area were rice straw (60.7%), maize stovers (5.3%), teff straw (24.4%), and legumes straw (9.6%). As indicated in Figure 3, rice crop farm lands were expanding at a significant rate in Fogera plains and uplands and contributed a significant share it for food to humans and as feed for livestock.

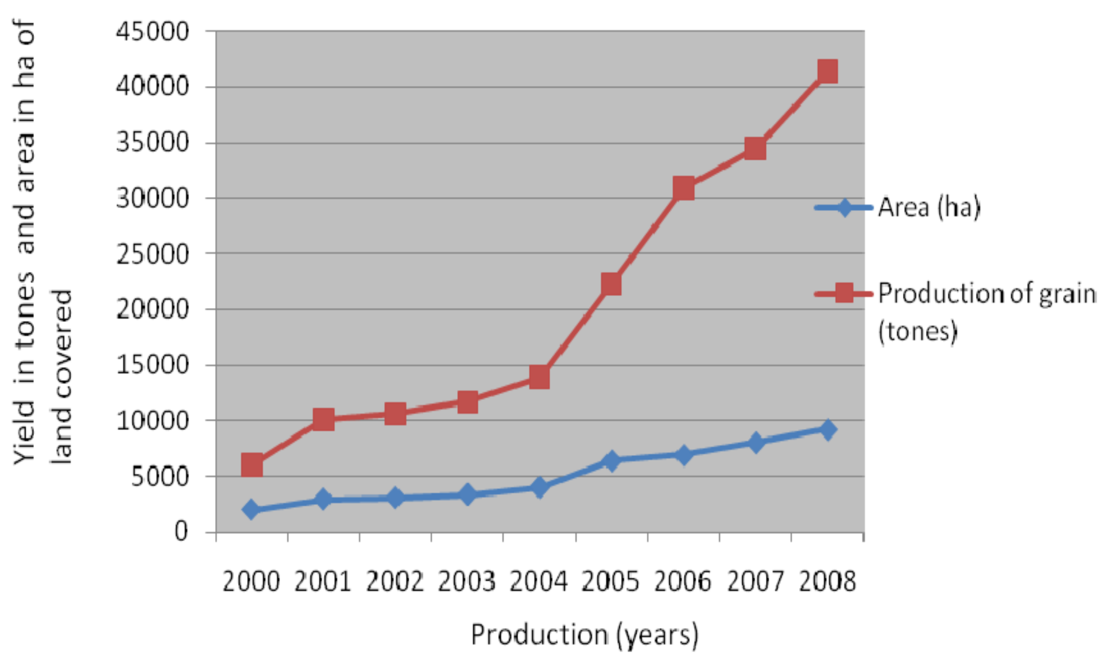


Figure 3. Rice crop area coverage and yield in Fogera Woreda

According to the study conducted on the potential yield assessment of rice crop in Fogera on three rural PAs at Shina, Kuhar Michael, and Addis betechristian, the mean yields were found to be 4.8 tons/ha unhulled rice, 3.36 tons/ha of white rice (dehulled rice grain) and 4.19 tons DM rice straw/ha (Table 8). In the study area, the estimate index of rice grain to rice straw was found to be 1:1.25 ratios of rice grain and rice straw ranging from 1:0.97-1:1.4. Whereas rice bran was estimated from the rice grain obtained during the polishing process and founded as 0.1 kg/kg (10%) of rice grain production. Based on the above multiplier estimate of rice grain production in the study area, it was possible to produce 3.36 ton/ha of rice grain and 4.19 ton/ha of rice straw DM. Taking in to consideration of the area of cultivated land covered with rice crop, it is estimated 30,956 tons of white rice, 38,603 tons rice straw DM, and 4,422 tons rice bran was produced in Fogera woreda in 2008. In the study area; a mean yield of 4.19ton DM rice straw was produced per household, where the maximum yield per household was 12.57ton DM rice straw a year.

Table 8. Rice productivity in terms grain, straw yield and nutrient composition in Fogera woreda

PAs	Grain yield (ton/ha)		Straw DM (ton/ha)	DM%	Ash%	Protein	NDF	ADF
	unhulled	dehulled						
Shina	5.32	3.72	4.87	97.72	14.52	3.16	66.44	48.51
Kuhar Abo	4.85	3.39	4.86	94.65	16.46	4.22	68.46	49.06
A/betechristian	4.24	2.96	2.87	94.69	12.53	2.68	73.78	50.02
Mean	4.8	3.36	4.19	95.69	14.50	3.35	69.56	49.20

ADF= Acid detergent fiber; DM = Dry matter; PA= peasant association (Kebele); NDF = Neutral detergent fiber

4.5. Chemical Composition and *In-vitro* Organic Matter Digestibility of Feeds

The chemical composition of experimental feeds was presented in Table 9. The percentage composition varied depending on feed type, in which the contents of CP were higher in the concentrate mix and rice bran. The relatively higher contents of CP, in the concentrate mix and rice bran than in straws revealed their paramount nutritional importance to augment ruminants on poor quality roughages. Urea treatment increased CP content of the straw more than doubling in percentage units from 3.35% (30.99g/Kg DM) to 7.54% (70.21g/Kg DM), increased by 125%, due to binding of ammonia to the straw (Srinivasulu *et al* 1999). There was also an increase in IVOMD from 30.8 to 49.4% (increased by 8.26%) due to better solubilization of hemicellulose and swelling of cellulose during urea treatment (Singh *et al* 2001) that agrees with that reported by Preston and Leng (1987); who reported that treatment of straw increases digestibility by 5-10% in line with the nitrogen contents of the treated straw as compared to the untreated straw.

On the other hand, cell wall components were also affected by urea treatment by reducing the NDF and hemicellulose contents of rice straw by 10.3% and 39.89%, due to binding of ammonia with straw and solubilization of hemicellulose by the action of ammonia evolved from urea (Srinivasulu *et al* 1999; Misra *et al* 2006). Rehrahie (2001) reported that urea treatment of barley and teff straw had contributed the straw to increased nutrient availability as animal feed. Urea treatment has no significant effect on the EME value of roughages, but it makes available for digestion cellulose and hemicellulose for microbial fermentation, thus raising EME content (Orskov, 1987).

The supplements (concentrate mix and rice bran) had the higher CP and lower NDF concentrations relative to the basal diet (UTRS). The concentrate mix had CP contents greater than 15%, a level that is usually required to support lactation and growth, while rice bran was lower than 15% that needs to supplement other feeds (Norton, 1982). According to Singh and Oosting (1992), roughages with NDF content of 45-65% are generally categorized as a medium quality feed, while feeds with NDF below 45% are grouped as high quality feeds and feeds with NDF above 65% are grouped as low quality feeds. The rice bran and concentrate mix used in the present study with an NDF value of

37.62% and 34.49% fall in the category of high quality feeds, while urea treated and untreated rice straw with respective NDF value of 69.56% and 77.55% fall in the category of low quality feeds.

The low levels of NDF in both rice bran and concentrate mix are indicative of high cell soluble matter. The ADF fraction in rice bran was slightly lower than that observed for concentrate mix and accounted for about 23.47% of the NDF, further signifying the low content of lignin and high levels of hemicelluloses. Rice bran and concentrate mix supplements used in the present study can fully replace each other and fall into high quality feedstuff categories. Thus, there is an enormous potential for rice bran to be used as a supplement to low quality basal feeds partially replacing conventional concentrates.

Table 9. Chemical composition, *in-vitro* organic matter digestibility and estimated metabolizable energy of feeds

Measurement	Untreated rice straw	Urea treated rice straw		Rice bran	Concentrate mixture
		Offer	Refusal		
DM (g/kg)	955	954	945	936	933
CP (g/kg DM)	31.99	71.93	70.21	108.58	162.53
Organic matter (g/kg DM)	816.52	792.3	793.33	821.43	824.59
Ash (g/kg DM)	138.48	161.70	151.67	114.57	108.41
NDF (g/kg DM)	740.60	663.60	664.33	352.12	321.79
ADF (g/kg DM)	469.86	501.04	481.95	219.68	230.08
Hemicellulose (g/kg DM)	270.74	162.56	182.38	132.44	91.71
IVOMD (%DM)	30.8	49.40	52.30	67.30	78.6
EME (MJ/kg DM)	7.30	7.90	8.37	10.77	12.58

ADF = acid detergent fiber; CP = crude protein; DM = dry matter; EME = estimated metabolisable energy ME=0.16 (% IVOMD); IVOMD = *in vitro* organic matter digestibility NDF = neutral detergent fiber.

4.6. Feed Intake and Daily Body Weight Change

The result of supplementation on DM and nutrient intakes are presented in Table 10. Cows fed on T_4 (UTRS + concentrate mix) had consumed 0.74 kg/ day, 0.49 kg/day, and 0.13 kg/day more DM than those maintained on T_1, T_2 and T_3, respectively. Total DM intake across all dietary treatments seems to have followed the same trend. There was still numerically some advantage in UTRS and total DM intake when the UTRS and rice bran supplemented group T_4 was compared with the control group. Rai *et al*. (1989) indicated feed intake values for treated rice straw was as large as 2.46 kg/100 kg LW.

According to Mukassa-Mugerwa (1989), lactating cows will probably lose weight after calving, but weight loss should be minimized through good feeding to allow them to start cycling again and to allow annual calving. During the early lactation (first three months after calving) all cows in the current study lost body weight, with a declining trend with advance in lactation. Requirements for the observed daily mean milk yield (2.31 kg/day) from this trial were not met at all levels of supplementation; but the estimated MEI requirement (63MJ/day) for maintenance and milk production of lactating dairy cow weighing 250 kg (average body weight of the experimental animals) and producing 4-6 kg/day milk of 4.5% butter fat (ARC, 1990). Total ME intakes were lower as compared to requirements (ARC, 1990) and hence during early lactation it has been utilized the body reserves for increased milk yield and thus cows lost body weight during this stage of lactation. The loss in body weight of cows during early lactation (60-90 days after calving) was reported by Azage *et al.* (1994). Muinga *et al.* (1992) also noticed body weight loss for the entire lactation period ranging between –20 to -90 kg for lactating crossbred cows fed *ad lib* napier grass fodder and supplemented with 0.4 or 8 kg/day of fresh leucaena forage from day 15-112 of lactation. Garnsworthy (1997) noted that cows in early lactation and those of higher genetic merits partition energy towards milk production at the expense of body fat reserve. This author further noted that cows normally lose 0.5-1.0 kg of body weight each day for the first eight weeks of lactation and this is mostly from body fat reserve. The finding from this trial clearly supports the idea suggested by Preston and Leng (1986) that molasses or alkali treated straw based diets are more digestible, but they support little improvement in animal productivity unless they are supplemented with by-pass nutrients.

Table 10: Nutrient intake of experimental cows fed four experimental diets

Measurements	DMI (kg/day)	CPI (kg/day)	NDFI (kg/day)	ADFI (kg/day)	MEI (MJ/day)
T_1	2.17^a	0.07^a	1.51^a	1.07^a	15.84^a
T_2	2.42^a	0.18^b	1.88^b	1.47^b	19.12^b
T_3	2.78^b	0.25^c	1.78^b	1.33^b	29.94^c
T_4	2.91^b	0.31^d	1.85^b	1.43^b	36.61^d
Mean	2.56	0.18	1.75	1.32	25.38
Significance (P<0.05)	*	*	*	*	*
SE	0.25	0.01	0.19	0.15	0.34
CV%	9.95	4.3	11.1	11.34	1.34

^{abcd}= within column, means with different superscripts are significantly different (P<0.05); ADFI = Acid detergent fiber intake; CV= coefficient of variation; CPI = Crude protein intake; MEI = Metabolisable energy intake; NDFI = Neutral detergent fiber intake; SE= Standard error; TDMI = Total DM intake; T_1= *ad lib* untreated rice straw (Control); T_2 = *ad lib* urea treated rice straw; T_3= *ad lib* urea treated rice straw + Rice bran; T_4= *ad lib* urea treated rice straw raw + Noug cake and rice bran (concentrate mix)

Therefore, increased energy intakes at this stage of lactation is expected to result in further increases in milk yield, if the cow's genetic potential has not been reached and/or a reduction in the daily amount of body fat mobilized. Cows fed untreated rice straw and other dietary treatments were significant (P<0.05) in daily body weight loss of cows (Table 11). Cows of the present study were losing body weight progressively during the first period of the lactation cycle which can be attributed to peak lactations and deficiency of daily nutrient requirements. They have shown a mean live weight loss (-420 g/day) of which the control group that fed sole untreated rice straw have shown a maximum weight loss (844 g/day). Regarding to other treatment groups, those fed urea treated straw have got a weight loss of (400 g/day), while cows fed rice bran and concentrate mix with urea treated rice straw indicated a weight loss of 244 g/day, and 177 g/day, respectively. As to the current result, even if there was a weight loss, the rate of loss in cows fed untreated rice straw was significantly higher (P<0.05) than that observed in the other treatments.

Table 11. Effect of feeding urea treated rice straw and concentrate on body weight change

Measurements	Initial weight (kg)	Final weight (kg)	Weight loss (kg)	Daily weight loss (g/day)
T_1	250[a]	211 [a]	-38 [a]	-844[a]
T_2	267[a]	254 [a]	-18 [b]	-400[b]
T_3	265[a]	254[a]	-11 [b]	-244[b]
T_4	2.53[a]	245[a]	-8 [b]	-177[b]
Mean	259	241	19	-420
Significance (P<0.05)	NS	NS	*	*
SE	34	32	7.9	175
CV%	13	13.5	41	41

CV= coefficient of variation; SE= Standard error; T_1= *ad lib* untreated rice straw (Control); T_2 = *ad lib* urea treated rice straw =; T_3= *ad lib* urea treated rice straw + Rice bran; T_4= *ad lib* urea treated rice straw raw + Noug cake and rice bran (concentrate mix)

4.7. Milk Yield and Composition

Milk composition and production are the interaction of many elements within the cow and external environments (O'Connor, 1994). High milk yield of satisfactory composition is the most important factor ensuring high economic returns. If the composition of milk varies widely, its implication is that food value and its availability as a raw material will also vary. Feeding of urea treated rice straw alone had given an extra milk yield of 1.16 kg of milk in lactating animal per day in the study area, which is a similar as 1-1.5 kg milk per day reported by (Khan and Davis (1981); and Pedock *et al* 1982). Similar results were also reported by Mesfin *et al* (2009), and Getu (2006) indicated that cows fed urea treated teff straw and wheat straw respectively had significantly higher milk yield than for non-supplemented animals of cross bred cows. There was significant difference (P<0.05) between the supplemented and non- supplemented groups in milk yield of lactating Fogera cows.

Table 12 Milk yield and composition of lactating cows fed experimental feeds

Treatment	**Mean Milk yield(kg/d)**	**Milk composition(%)**				
		Fat	**Protein**	**TS**	**SNF**	**Ash**
T_1	1.20^{b}	4.16^{a}	2.78^{ab}	12.72^{a}	8.55^{a}	0.518^{a}
T_2	2.36^{a}	3.56^{ab}	2.84^{ab}	11.51^{b}	7.95^{a}	0.644^{a}
T_3	2.48^{a}	3.43^{ab}	3.18^{a}	11.50^{b}	8.06^{a}	0.497^{a}
T_4	2.63^{a}	2.86^{b}	2.66^{c}	11.47^{b}	8.60^{a}	0.515^{a}
Mean	2.31	3.50	2.86	11.80	8.29	0.543
Significance (P<0.05)	*	*	*	*	NS	NS
SE	0.05	0.43	0.20	0.56	0.55	0.12
CV%	11.04	12.5	7.15	4.82	6.68	21.79

^{abc}= within column, means with different superscripts are significantly different (P<0.05); T_1= *ad lib* untreated rice straw (Control); T_2 *ad lib* urea treated rice straw =; T_3= *ad lib* urea treated rice straw + Rice bran; T_4= *ad lib* urea treated rice straw raw + Noug cake and rice bran (concentrate mix); SED = standard error of difference; CV= coefficient of variation; NS=Not significant; TS=Total solids; SNF=Solid-Non-Fat; *= significant(P<0.05)

The mean milk yield of lactating cows in Fogera was 2.31 kg/day and with a composition of 3.5% fat, 2.86% CP, 11.8% TS, 8.29% SNF, and 0.543% ash, which is lower than reported by Asaminew (2007) at Mecha and Bahir Dar Zuria that had overall mean fat, protein, total solids, ash and solids-not-fat (SNF) contents of 4.71%, 3.25%, 13.47%, 0.73%, and 8.78%, respectively. This might be due to intrinsic factors like breed, parity, stage of lactation, external factors like environmental stress, and changes in feeding. Schaar *et al*. (1981) reported 6.15% fat in Fogera cows' at their first lactation. These differences may be due to, differences among individuals within a breed (O'Connor, 1994) which could be partly genetic and partly to environmental factors.

Cows fed untreated rice straw significant difference (P<0.05) in fat composition of milk compared to UTRS and concentrate diets as indicated in (Table 12). Nutrition has effect on milk fat composition as T_2, T_3, and T_4 shown a decreased in percentage of 0.6, 0.73, and 1.3, respectively. According to O'Connor (1994), any ration that increases milk production usually reduces the fat percentage of milk. It is also believed that the fat content is influenced more by roughage (fiber) intake and the solid-non-fat content can fall if the cow is fed a low energy diet. In temperate type cows, the fat and SNF percentages tend to be higher in the early weeks of lactation, dropping by the third month then rising again as milk yield gradually declines (O' Manhony, 1988).

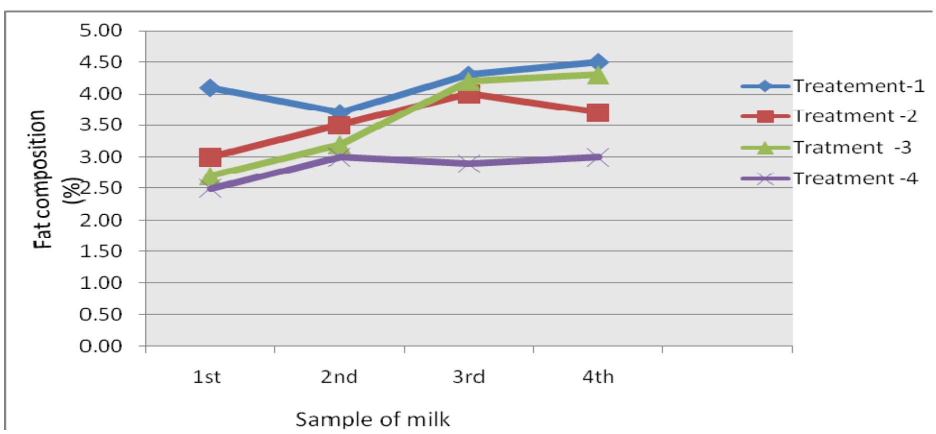


Figure 4. Trends in fat composition of milk samples taken at different times from lactating Fogera maintained on grazing and supplement

Similarly, the high milk protein content observed in urea treated rice straw and rice bran supplemented cows (3.18 %) in the current study compared to others, which could be attributed to the high protein intakes of the cows (Khalilli *et al*., 1994; Mpairwe, 1998) (Table 12; Figure 5) and also reported by Phipps (1994) high protein intake increases milk yield and milk protein concentration. The present finding was in line with Hill and Leaver (1999) which states that milk protein concentration is affected by the level of concentrate rather than the CP concentration.

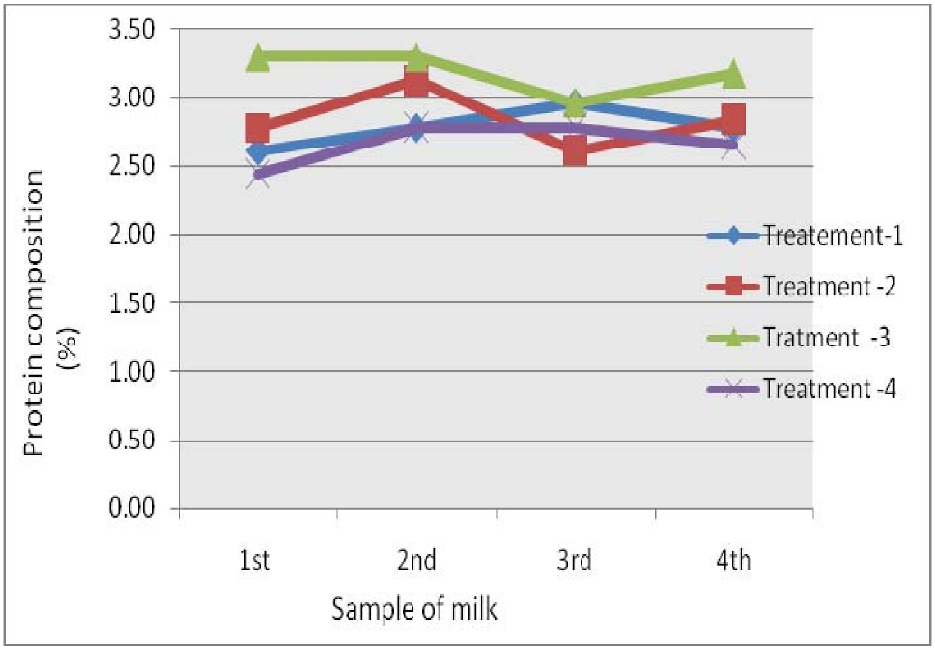


FIgure 5. Trends in protein composition of milk samples taken at different times from lactating fogera maintained on grazing and supplement

The composition of total solid was associated with fiber content of feeds as can be seen from (Table 9; Table 10), that intake of diets with high NDF might be contributed to higher total solid. As a result cows fed untreated rice straw has shown higher total solid percentage composition in their milk samples.

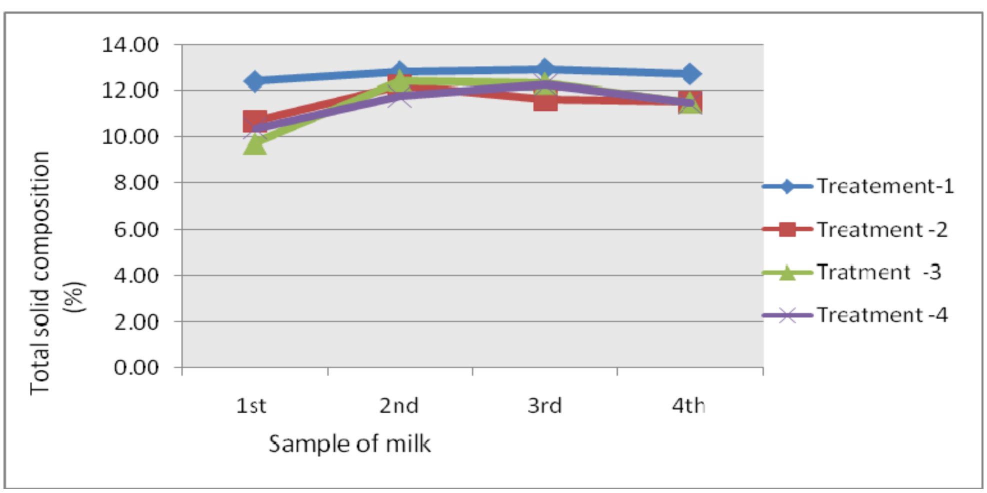


Figure 6. Trends in total solid composition of milk samples taken at different times from lactating Fogera maintained on grazing and supplement

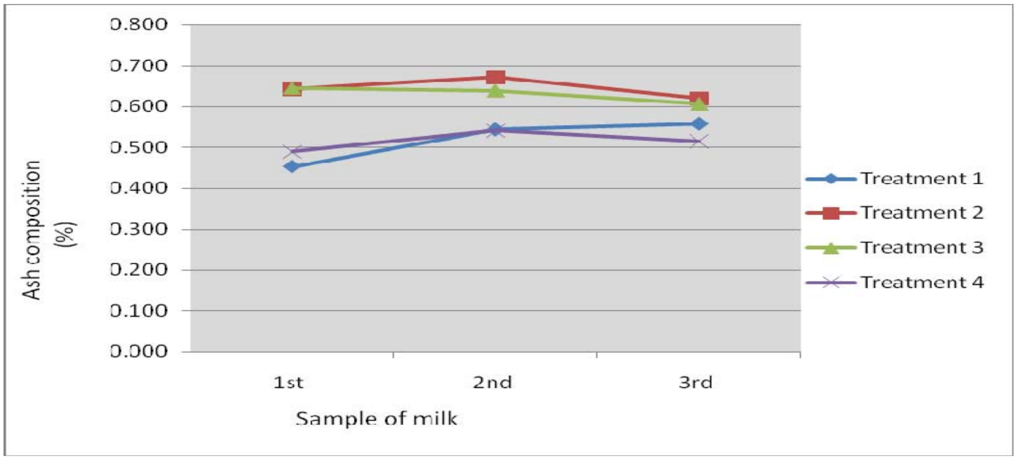


Figure 7. Trends in ash composition of milk samples taken at different times from lactating Fogera maintained on grazing and supplement

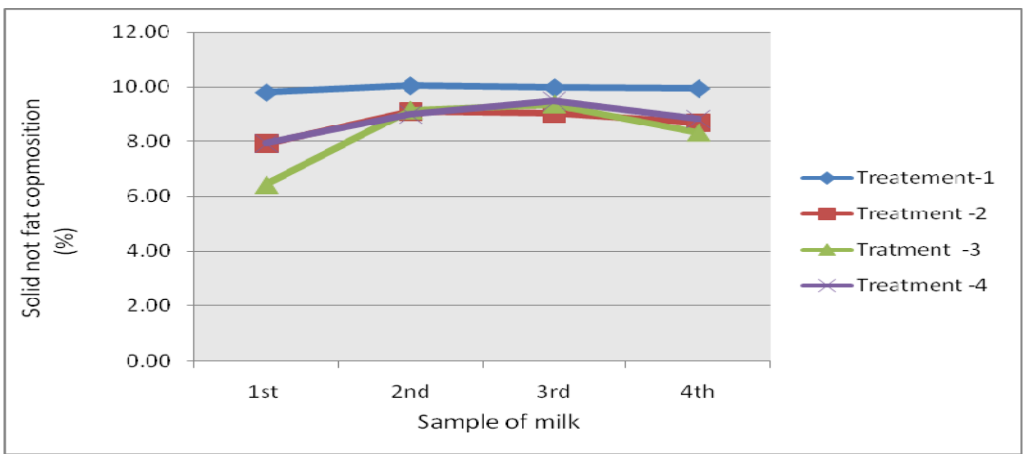


Figure 8. Trends in SNF composition of milk samples taken at different times from lactating Fogera maintained on grazing and supplement

The milk yield record of early lactation (Figure 9) represented the lactation period of 45 days, and supplemented groups of T_2, T_3, and T_4 had given mean milk yield of 2.36, 2.48, and 2.63 kg/day respectively which was closer to the mean milk yield (2.9 kg/cow/day) of Fogera cattle reported by Zewdu, (2004). This revealed that supplementation of dairy cows in the dry season has significant effect in milk yield that enables the cows to maintain and produce to their capacity, while the control groups have shown a decrease in milk yield and to even gone to dry off specially in March and April when severe feed shortage occurred.

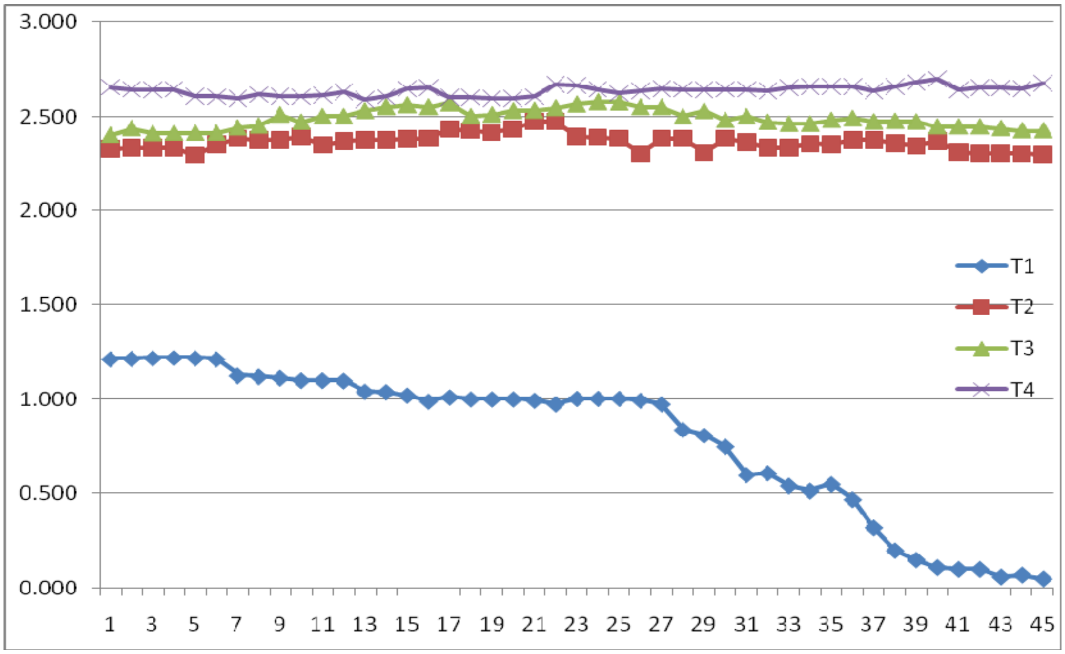


Figure 9: Lactation curve of cows fed on experimental diets

4.8. Relationship among Parameters

Pearson correlation values among intake, milk yield and composition, and live weight change are given in Table 13. Positive and significant (P<0.05) linear correlations (r = 0.931, 0.945, and 0.919) were observed between the respective CPI, NDFI, ADFI and milk yield, indicating good contribution of increased intake of CP, NDF, and ADF to the increment of milk yield of Fogera cows in this study.

However, milk composition was poorly correlated (P>0.05) with intakes of ADF and NDF. Both intake in DM, CP, NDF, ADF, and ME have negative correlation with fat percentage composition, but intake of DM, and CPI were negatively and significantly (P<0.05) correlated (r = -0.935, and -0.976). DMI, and CPI were negatively and significantly (P<0.05) correlated (-0.941, and -0.972). Protein composition of milk has no significant (P>0.05) correlation to intake in DM, CP, NDF, ADF, and ME, where ADF had negative correlation.

Table 13. Correlation among parameters of intake with body weight change, milk yield and composition of Fogera cows

Variable	Milk yield	Fat %	Protein %	Body weight change
DMI	0.876^{ns}	-0.935^{*}	0.151^{ns}	-0.941^{*}
CPI	0.931^{*}	-0.976^{*}	0.069^{ns}	-0.972^{*}
NDFI	0.945^{*}	-0.803^{ns}	0.054^{ns}	-0.886^{ns}
ADFI	0.919^{*}	-0.789^{ns}	-0.16^{ns}	-0.854^{ns}
MEI	0.776^{ns}	-0.922^{*}	0.16^{ns}	-0.860^{ns}

ADFI = acid detergent fiber intake; CPI= crude protein intake; DMI= dry matter intake; MEI= metabolizable energy intake, NDFI= neutral detergent fiber intake; ns = not significant; * = significant (P<0.05)

4.9. Economics of Supplementation of Dairy Cows Fed Urea treated Rice Straw, Rice Bran and Concentrate Mix

Economic feasibility of this experiment was analyzed using partial budget. The cost of grazing for the control groups was not considered, while the total cost of production (feeds, urea, and material including plastic sheet used for ensiling the rice straw) was considered since other variable cost (medicaments) was the same for the entire groups. According to this analysis, T_2 gave the highest net benefit (6.82 ETB per cow/day), while T_1 gave the lowest net benefit (4.20 ETB per cow/day) (Table 10). The net profit increased from ETB 4.20/cow/day in T_1 to 6.82, 6.50, and 6.59 ETB for T_2, T_3, and T_4, respectively. The overall rate of change in net profit over the control group was 2.62 ETB/cow/day for T_2; 2.30 ETB/cow/days for T_3, and 2.39 ETB/cow/day for T_4. Hence, this study demonstrated that supplementary feeding of UTRS, RB, and concentrate mix for Fogera milking cows increased the net profit for farmers.

The minimum rate of return acceptable by the dairy farmer was assumed to be 50% (CIMMYT, 1985). This implies that the dairy farmer expects a minimum rate of return of 50% if he/she is to adopt a new practice as compared to the practice he/she used to do. In this experiment, the rate of return was above the recommendation of CIMMYT (1985) that could be easily adopted since, economic benefits realized from the supplementation of crop residues are mostly assessed based on the balance between the biological outputs (in terms of milk yield) and cost of purchased of inputs.

Similarly, in Asia, where straws are commonly used as a ruminant feed, urea/ammonia treatment with supplemental nitrogen and minerals was observed to have boosted productivity more economically than feeding cereal based concentrate supplements (Jayasuriya, 2001). However, drawing standard conclusion on the economic feasibility of supplementation of urea treated rice straw, rice bran and concentrate for dairy cows, requires observing the trend of milk production for whatever dietary treatments considered throughout the lactation period.

Table 14. Partial budget analysis for lactating Fogera cows fed ad lib urea treated rice straw and supplemented with rice bran and concentrate mix

Variables	T1	T2	T3	T4
Cost of urea (ETB)	-	30.68	30.68	30.68
Cost of plastic (ETB)	-	15.00	15.00	15.00
Cost of labor (ETB)	-	20.00	20.00	20.00
Cost of rice bran (ETB)	-	-	33.75	-
Cost of Concentrate (Noug cake + rice bran + salt)	-	-	25.50	27.50
Total Variable cost (ETB)	0.00	328.40	497.15	593.40
Cost /cow/experimental period (ETB)	0.00	65.68	99.43	118.68
Cost/cow/day (ETB)	0.00	1.46	2.21	2.64
Mean kg of milk/treatment/day (ETB)	1.2	2.36	2.48	2.63
Cost /cow/kg of milk (ETB)	00	0.62	0.89	1.00
Gross income from sale of milk/day, ETB"	4.20	8.28	8.71	9.23
Net profit, ETB	4.20	6.82	6.50	6.59
Net profit over the control/treatment/day ETB	-	2.62	2.30	2.39

*Price per litre of milk is fixed to be 3.50 ETB ETB = Ethiopian birr

4.10. Farmers' Perceptions

Farmers' feedback assessment made at the end of the experimental period on the efficiency and adoption of the technology revealed that farmers don't have the knowledge and skill on how to treat rice straw with urea. They claimed that, but the extensionists were telling them simply the theory on the importance of treating rice straw. They have appreciated that treatment of rice straw with urea improved palatability, softened the straw and showed better response in milk yield and body weight of their cows during peak feed shortage season. To promote this technology, practical observation, and skill development of both extensionists and farmers as well as establishing the system of availing fertilizer grade urea during dry season is required. Farmers underscored that the rice bran they produce is simply sold to the benefit of traders (rice polisher owners) and sold to other areas for fattening purpose. They also indicated that, since grazing lands have been transformed to crop land and even the available pasture land is invaded by a noxious weed called amiclala (*Hygrophila auriculata*), the potential of rice straw and rice bran available in their area; farmers' said, should be utilized effectively to sustain their animals.

The farmers also underscored that the unavailability of urea fertilizer (especially in the dry season) to be the shortcoming for the adoption of urea treatment technology, and technical assistance of experts has to be improved and close supervision is required until the skill of farmers in managing urea treated straw is well developed.

5. CONCLUSIONS AND RECOMMENDATIONS

The study was conducted at Fogera woreda with the objective of assessing the production practices, productivity and evaluating the overall supplementary value of urea treated straw, rice bran, and formulated concentrate mix. The experiment consisted of survey of rice feed resource production, utilization practices, and feeding trials using twenty Fogera lactating cows of similar milk yield with a range of 1-2 kg/day, body weight and stage of lactation (early lactation) for a lactation period of 45 days.

Results from the survey indicated the availability of huge production of rice grain and its by-products, and expanding opportunity of rice production in the study area, where the estimated production of rice straw could be 44,223 ton in rice grain and 38,603 ton DM rice straw. Rice bran yield is also estimated at 4,422 ton/ year. The survey analysis depicts rice covers 50% of the land in rice growing PAs and accounts 60.7% of the feed resource. This indicates that rice is the main feed resource to livestock development in the study area, while the utilization practice is limited to dry season and lacks efficient and systematic feeding system. Besides, farmers considered it as a useless feed resource, but fed to sustain the life of their animals during peak dry season not for production target. The rice bran was also considered as waste and not yet utilized still for animal feed. But, it has a CP content of 11.6 and IVOMD of 67.3%. These all show feeding value of rice bran should not be neglected but given due attention. The feeding experiment indicated that supplementation of urea treated rice straw has resulted in increased milk yield by 1.16 kg/cow/day and rice bran by 1.28 kg/cow/day as compared to the farmers practice (1.2 kg/cow/day). The control groups not only had a decreased milk yield but even went to dry off especially in March and April when severe feed shortage occurred. Supplementation of urea treated rice straw resulted in a net profit increment from 2.62 ETB/cow/days as compared to the farmers practice, and 2.30 and 2.39 ETB/cow/day as compared to supplementation of urea treated rice straw with rice bran and concentrate mix, respectively. Since both resources (rice straw and rice bran) are available in large quantity and with cheaper price, supplementation of urea treated rice straw (T_2) and with rice bran (T_3) are important feeding packages for the study area. Although, the existing scenario on milk yield indicated improvement due to urea treatment of rice straw, additional observations to see the probability of lactation curve for all dietary treatments in the remaining part of the lactation cycle for conclusive economic decision should be made. However, since the cost for most inputs are variable over time, it cannot be taken for granted that the net benefit obtained from concentrate mix could also be sustainable over years or locations; but as far as the cost of production and the sale price of milk remains constant, this recommendation is valid at least in the area where this experiment has been conducted. Generally, treatment of rice straw with fertilizer grade urea and feeding with rice bran, have a paramount importance to develop dairy business of smallholder farmers in the study area. As a result, smallholder dairy producers, extension workers, development organizations as a whole should stress on the improvement and adoption of these technologies of rice straw and rice utilization as animal feed resource in the study area.

FURTHER SCOPE OF WORK

- Further study is required to assess the effect of supplementary urea treated rice straw on lactation milk yield and economic feasibility
- Since farmers have the practice of utilizing green forage legumes such as grass pea (Guaya) in peak dry season further investigation on substitution effects of these forage legumes for concentrates is required
- Additional investigation is required on supplementation and preparation of rice bran as a multi nutrient block
- Targeted farmers that are more beneficial in milk production and innovative farmers who are also involved in milk marketing should get especial attention and make them to play their role in adoption of these technologies.

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7. APPENDICES

Appendix Table 1: ANOVA table or milk yield and composition

Sources	DF	Sum of squares	Mean squares	F value	P>F
Milk yield					
Model	7	6.81	0.97	24.96	0.0001
Error	12	0.468	0.039		
Total fat					
Model	5	4.11	0.82	4.27	0.05
Error	6	1.155	0.19		
Total protein					
Model	5	0.55	0.11	2.62	0.136
Error	6	0.25	0.04		
Total solids					
Model	5	9.4	1.88	5.81	0.027
Error	6	1.94	0.32		
Ash					
Model	5	0.044	0.008	0.62	0.68
Error	6	0.084	0.014		
Solids-not-fat					
Model	5	3.73	0.74	2.43	0.15
Error	6	1.84	0.31		

Appendix Figure 1. Withdrawing of urea treated rice straw from pit by feeding experiment participants farmers

Appendix Figure 2.Daily milk yield measurement of participant farmers

Questionnaire on Rice Production and Rice Straw Utilization Assessment

Date ______________ Enumerators name __________________________ Woreda ____________ Kebele ____________Village _____Farmer's name______

Age_______________ Educational level (0= illiterate, 1= 1st grade, 2nd grade…) ___________

1. **Family size:** Male_______ Female ______ Total ___________

   1.1. **Age distribution** 0-14 _______ 15-64 ______ above 64______________

2. **Landholding in timad:** Total ______ Owned land ____ Rented land_______

Crop year _____

Table1. Crop production distribution of farmers

No	Crop type	Coverage in timad		Yield per timad	Place of production land	
		Owned	Rented		Soil type(black, brown, mixed, red)	Water retention nature (sloppy, logging, medium)

3. **Livestock holdings:**

Cow_____ Ox _____ Calf ____ Heifer ____ sheep ____ Goat ___

Mule_________ Donkey_____Horse _____ Chicken _____bee colony ____

Table 3. Livestock breed ownership assessment

No	Breed type	Number	Purpose	Remark
Local				
Exotic				
Cross				
Mixed				

Which livestock species population has decreased/ increased? Rate the extent of change on a scale: 1= decreased substantially (− −), 2= decreased slightly (−), 3= no change (0), 4= increased slightly (+), 5= increased substantially (+ +); and identify main causes of the changes.

Table 4. Livestock population trend

No	Species	Rate	Reasons of change
1	Cattle		
2	Sheep		
3	Goat		
4	Equines		
5	Poultry		
6	Bees		

What are the main constraints to livestock production in prioritizing order? And rank them.(Feed , house, disease, breed, land, capital, market …)

Table 5. Livestock production constrains assessment

No	Constraints	Priority	Reasons of being get this priority	Efforts made to avoid these constraints

4. Feed constraints assessment

Tabl 6. Feed constraint assessment

Constraint – feed	When faces?	Which animal severely affected
Do you encounter feed shortage?		
Yes		
No		
When occur?		
Wet season		
Dry season		
Do you supplement?		
Yes		
No		

5. Feed resources utilization assessment

Animals of Priority (1= cow, 2= ox, 3= heifers, 4= calf, 5= sheep, 6= goat, 7= equines, 8= poultry), Season (1= summer, 2= winter, 3= autumn, 4= spring, 5= year round), Time of feeding (1= morning, 2= afternoon, 3= day, 4= night, 5= no specification), Feeding system (1= stall feeding, 2= free access, 3= mixing with others, 4= sole feeding),and improvements(1= mixing with others, 2=chopping, 3=ensiling with urea, 4= sowing with legume species,5=cut and carry system)

Table 7. Feed resources and utilization

No	Feed resources	Contribution (% share)	Animals given priority and reasons	Time of feeding (time and season)	Feeding system	Improvements systems made

6. **How has the availability and use of feed resources**

For dairy cattle changed since 1990 E.C in your village? Rate the extent of change on a scale: 1= decreased substantially (− −), 2= decreased slightly (−), 3= no change (0), 4= increased slightly (+), 5= increased substantially (+ +); and identify the main effects of the changes.

Table 8. Historical matrix of availability, quality and use of feed resources

Main sources of feed for dairy cattle	Rank availability during wet season (1 = being the first most available)	Rank availability during dry season (1 = being the first most available)	Rate the extent of change in availability since 1996 EC	Main causes

7. **Grazing land utilization**

7.1. Grazing land in ha: private ________ Communal __________

Time of grazing: - for private _____to_____, or year round ___

for communal _____to_____, or year round ___

For what length of time animals graze on the grazing lands?

Could you understand to what level of animal requirement grazing lands provide feed for our animals? (0= none, 1= ≤25, 2=26-50, 3= 51-75, 4= 76-100)

What is the trend of grazing land in area coverage and productivity? (1= decreased substantially (− −), 2= decreased slightly (−), 3= no change (0), 4= increased slightly (+), 5= increased substantially (+ +); and identify three main causes and effects of the changes.

Table 9. Historical matrix of availability and quality of communal grazing areas

	Rate the extent of change (1-5)	Main contributing factors	Effects
Communal natural pasture areas?			
Quality of communal natural pasture areas?			
Water availability for livestock?			

8. What are the problems in grazing land utilization?

9. Options that you suggest to be done for the grazing land improvement works in the future?

10. Crop Residues

1. Source of crop residues (list in decreasing order of production level)

Table10. Management and utilization of the crop residues summary

No	Crop residues used	Amount produced	Amount of feeding/ day	Animals fed
1				
2				
3				
4				
5				
6				

2. **Trend of crop residues production**

Trend (Rate the extent of change on a scale: 1= decreased substantially (− −), 2= decreased slightly (−), 3= no change (0), 4= increased slightly (+), 5= increased substantially (+ +); and identify the main effects of the change)

No	Crop residues	What trend	Causes of change	Is it balanced to the feed requirement?	By what you balance?
1					
2					
3					
4					
5					
6					
7					

11. Rice production in Fogera

1. When do you started to produce rice?
2. Why do you started to produce rice? Preference/ reasons (feed, food, market…)
3. Total ___________ Owned land __________ rented land_________in timad
4. Grain yield per timad _______ Part of the plant used for feed (1= straw, 2= rice bran, 3= rice husk, 4= rice grain)
5. What was amount of land/ timad do you produce rice before ten years? (Try to estimate over the ten years data of a farmer)
6. What type of crop do you use your farmland before the introduction of rice? (Crops land substituted by rice land)
7. What is the effect of rice production expansion on the availability and access of animal feed resources?

Table 12. Extent of rice straw and bran utilization for animal feed

Type	When fed (months)	Time of feeding (morning & afternoon)	Priority animal (given for delivery)	Yield (quintal per timad)
Rice straw				
Rice bran				

12. Rice straw

1. How do you determine the amount of straw and type of animal provide rice straw feeding?
2. Why? Reason of animal, amount, and time of provision required________________

3. How are the storage and utilization practices you use?
4. How is the marketing system of rice straw? (purchasing rate, system, time of sale of straw)
5. What techniques you use to improve rice straw?(chopping, mixing with other feed resources, treating with urea)
6. What are the constraints of rice straw production and utilization?
7. What are the opportunities of rice straw production and utilization?

13. Rice Bran

1. How do you determine the amount of bran and type of animal?
2. Why? Reason of animal, amount, and time of provision required________________

3. How are the storage and utilization practices you use?

4. How is the marketing system of rice bran? (purchasing rate, system, selling rate, time of sale of straw)

5. What are the constraints of rice bran production and utilization?

6. What are the opportunities of rice bran production and utilization?

14. Fodder production and utilization

1. Do you grow fodder crops?
2. If yes, which fodder crops?

3. If not, what are the reasons?

4. Do you provide supplemental feeds for your animals?
5. If yes, which type of supplement?
6. How do you get feed supplement?
7. Purchasing/ producing? Where?

8. For what type of animal you provide? (lactating, pregnant, calves, oxen, fattening animals etc)